

Article

Blended Intensive Programs as a Pedagogical Approach: Fostering Digital, Collaborative, and Intercultural Skills in Advanced Civil Engineering Education

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Abstract

This paper presents the design, implementation, and assessment approach of the Blended Intensive Program (BIP) “Towards Enhanced Pedestrian Safety”, developed under the Erasmus+ framework at the University of Beira Interior in collaboration with four partner universities from Slovenia, Poland, and Croatia. The study applies the EPIC framework (Embedded, Pluralistic, Internationalized, and Connected) to the design and evaluation of a short-term, hybrid, and international learning format in Civil Engineering, addressing a gap in the literature regarding the limited availability of structured and empirically grounded approaches for the design and assessment of Blended Intensive Programs in engineering education. The research presents an applied case study design in higher education supported by a mixed-methods approach, combining quantitative and qualitative data from a cohort of 25 participants across different academic levels. Data collection includes performance-based assessment (tests and project evaluation), structured surveys, and qualitative feedback. The program combined digital technologies, including GIS, machine learning, and video image analysis, with problem-based and collaborative learning in a hybrid format comprising 7 h online and 35 h in person. The BIP fostered both technical competences, such as road safety diagnosis and data-driven modelling, and transversal skills, including teamwork, communication, leadership, and intercultural competence. Results from student assessment and satisfaction surveys indicate high levels of engagement, motivation, and learning achievement. The findings provide empirical support for the applicability of the EPIC framework in the design and implementation of BIPs, demonstrating its adaptability to short-term, hybrid, and international learning contexts. The study highlights the pedagogical value of integrating international collaboration, digital tools, and active learning strategies, while aligning with SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities).

Keywords: civil engineering education; Blended Intensive Program (BIP); pedestrian safety; active learning; multicultural education; digital pedagogy



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1. Introduction

1.1. Framework

Ensuring pedestrian safety is a major challenge in today's urban mobility landscape. As vulnerable road users, pedestrians face higher risks in increasingly congested and multimodal streets. At the same time, cities are dealing with rising traffic volumes and competition for limited space (Eliasson & Proost, 2015), as well as the growing use of traffic calming and restrictive transport policies, such as parking limits and access controls (Banister, 2008). Thus, relying solely on reactive infrastructure or operations is insufficient. Effective pedestrian safety efforts require proactive, risk-informed strategies. These strategies must encompass risk diagnosis, targeted countermeasures, effectiveness evaluation, and consideration of road users' behaviors, needs, and expectations.

These challenges have a direct impact on engineering education. If graduates in transportation and road engineering are to contribute meaningfully to safety improvements, they need competencies that extend beyond applying standards and design procedures (Chen et al., 2024). It is not only important to know which parameters are recommended, but also to understand why they are relevant, particularly in relation to behavioral mechanisms and the biomechanics of pedestrian movement. Students are increasingly required to engage with empirical data, critically interpret results, communicate effectively with stakeholders, and collaborate within interdisciplinary teams (Crawley et al., 2014). In other words, road safety education should intentionally develop transversal skills alongside technical competencies. This suggests a shift toward pedagogical strategies that move beyond lecture-based instruction to emphasize authentic problem-solving, iterative design, teamwork, and reflection on real-world consequences, while maintaining continuity with foundational engineering knowledge acquired earlier in the curriculum (UNESCO, 2021).

Wider trends in higher education increasingly point toward and reinforce this approach. Internationalization places multicultural collaboration and communication at the core of engineering curricula (Crawley et al., 2014). Digitalization is equally influential: tools such as GIS, data-driven methods (including selected Machine Learning applications), and video image analysis increasingly shape contemporary engineering practice (Gal-Tzur & Albagli-Kim, 2024; Salunkhe et al., 2022). Concurrently, student-centered learning foregrounds learner agency and responsibility in decision-making processes and in the formulation of practically relevant conclusions (UNESCO, 2021).

In this context, Erasmus+ Blended Intensive Programs (BIPs) offer a coherent response. By combining virtual and physical mobility in a short, intensive format, BIPs facilitate joint learning experiences across institutions and support international teamwork on collaborative projects under the guidance of academic staff and invited experts. Their key added value lies in integrating hybrid learning, a digital learning environment, and practice-oriented tasks anchored in real problems, requiring students to mobilize both technical competencies and transversal skills (European Commission, 2024; Nortvig et al., 2018). This is consistent with previous case-based research in engineering education, where blended learning approaches have been systematically implemented and evaluated in authentic higher education contexts (e.g., Ożadowicz, 2020).

Despite the growing popularity of BIPs, the literature still provides limited, detailed evidence on how hybrid intensive programs are designed and evaluated in civil engineering, transportation engineering, and more specifically, road safety education. Studies rarely document the Program Design rationale, the selection of pedagogical and learning strategies and digital tools, or the approach to impact assessment. The existing literature places greater emphasis on program logistics and aggregate participant satisfaction than on structured and systematically evaluated approaches to program design and learning outcomes (Prada et al., 2025; Rasheed et al., 2020). This gap is particularly relevant in

the context of ongoing pedagogical transformation that foregrounds internationalization, digitalization, and student-centered learning.

This paper describes the design, implementation, pedagogical strategies and assessment of the Blended Intensive Program (BIP) “Towards Enhanced Pedestrian Safety” (TEPS), hosted in 2025 at the University of Beira Interior (Portugal). Developed in collaboration with partner universities from Slovenia, Croatia, and Poland, the study additionally examines the program’s impact on students’ technical and transversal skills.

1.2. Objective and Structure

The main objective of this study is to apply the EPIC framework (Embedded, Pluralistic, Internationalized, and Connected), a pedagogical model developed within a Portuguese PRR-funded initiative primarily aimed at fostering pedagogical innovation through the professional development of higher education teaching staff and the transformation of teaching practices at the level of curricular units (Consórcio EPIC, 2024), to the design, implementation, and evaluation of an Erasmus+ Blended Intensive Program (BIP) in Civil Engineering.

In doing so, the study addresses a relevant gap in the lack of evidence on how structured pedagogical frameworks can support the design and evaluation of Blended Intensive Programs in engineering education. Specifically, the EPIC framework has not originally been conceived for short-term, intensive, and international learning formats such as BIPs, nor for direct application within specific disciplinary contexts such as engineering education.

To address this gap, the study evaluates the applicability and adequacy of the EPIC framework within a BIP context by analysing program outcomes, including participants’ performance, survey results, and qualitative feedback. Accordingly, it adopts an applied case study design in higher education, supported by a mixed-methods approach that integrates quantitative and qualitative data from a sample of 25 participants across different academic levels. This design enables a comprehensive assessment of how EPIC principles can be effectively implemented in short-term, hybrid learning environments.

The remainder of this article is organized as follows: Section 2 provides a literature review on the evolution of engineering education; Section 3 details the methodology, including program design, pedagogical strategies, implementation and assessment methods; Section 4 presents the results and discussion across multiple evaluation components; and Section 5 offers final reflections, limitations, conclusions and future work.

2. Literature Review

Engineering plays a key role in addressing global challenges related to health, safety, and well-being, particularly within the framework of the Sustainable Development Goals (UNESCO, 2021; Gamage et al., 2022). In this context, the United Nations has defined a set of global priorities to be achieved by 2030 through the establishment of 17 Sustainable Development Goals (SDG). Among these, road safety is explicitly recognized as a global societal priority, especially in goal 3, where it is mentioned as central part of people’s wellbeing, and in goal 11, where the need for safer and more sustainable cities is stated (United Nations General Assembly, 2015). In parallel, higher education institutions are increasingly recognized as key actors in developing competencies related to sustainable cities and communities, particularly within SDG 11-oriented educational frameworks (Marcos-Sánchez et al., 2026).

To achieve these goals, technologically advanced approaches to road safety engineering are needed, as reflected in current industry trends. These include the deployment of Intelligent Transportation Systems (ITS) and Cooperative Intelligent Transportation Systems (C-ITS) (Meglič et al., 2025), the development of connected and automated ve-

hicles (Tibljaš et al., 2018) and significant improvements in the field of advanced sensing and computer vision (Donà et al., 2025). Further progress has also been achieved in the fields of traffic simulation techniques (Mustapha et al., 2024), Geographical Information Systems (Santos et al., 2024) and, more broadly, in big data-driven modelling (Skaug et al., 2025), all of which contribute to more robust road safety analyses. Clearly, road safety engineering is shifting from static approaches to data analysis and solution design towards real-time, largely data-driven modelling frameworks (Iwanowicz, 2023; Santos et al., 2026). To support the requirements of such a shift, higher education institutions must update their academic offering and learning frameworks. This configuration allows future engineers to master main technical competencies while simultaneously developing high-level transversal and interpersonal skills.

In this context, reviewing and summarizing the main engineering development milestones and the following educational (r)evolutions, defines the concept of Engineering Education (EE) 1.0, 2.0, 3.0, 4.0, and the oncoming 5.0 (Lantada, 2020). While EE 1.0 emerged following the First Industrial Revolution to train technical experts with a strong background in science and mathematics, EE 2.0, developed in the wake of the Second Industrial Revolution, shifted toward a more comprehensive and holistic professional training model. This shift emphasized the development of technical expertise alongside humanistic, societal, and artistic competencies. With EE 3.0, engineering education evolved to incorporate internationalized approaches and a stronger emphasis on experiential learning, marking the pivotal shift from analogue processes to digital environments. EE 4.0 represents the contemporary paradigm of engineering higher education. Tracing its origins to the late 1990s and seeing significant maturation through the early 2000s, this stage reflects the ongoing integration of advanced technologies, global connectivity, and a fundamental shift toward active learning methodologies. As Alfar (2025) noted, this trend has slowed down in recent years. However, demand for such innovative approaches remains stronger than ever.

Given the requirement for precise technical expertise, engineering curricula still rely heavily on traditional EE 1.0 pedagogical models (Lantada, 2020). Often described in the literature as lecture-based, these methods are characterized by content-intensive sessions where students primarily adopt a passive role, focusing on rote note-taking (Khoshnevisasl et al., 2014). It has been shown that such an approach, though efficient from a knowledge transmission viewpoint, has several weak points, such as poor retention of knowledge and the development of additional skills that are necessary for the current labor market (Devika et al., 2024). In fact, the rapid technological advancements of recent years have significantly amplified industry demands and reshaped the professional role of engineers. Modern engineers must possess not only technical expertise, but also essential cognitive competences, such as analytical thinking, complex problem-solving and technological literacy. These skills are intimately linked to transversal soft skills, including teamwork, leadership and effective communication (Alfar, 2025).

Students' profiles have changed alongside these technological shifts. While new generations demonstrate enhanced digital literacy, they also face a visible reduction in attention levels, requiring more engaging educational strategies (Siyami et al., 2023). This has a direct impact on the outcomes of traditional lecture-based approaches. Consequently, a pivotal shift toward the EE 4.0 paradigm is required, realigning the pedagogical focus from traditional, teacher-centered instruction to student-centered learning methodologies (Chen et al., 2024). Among student-centered methods, as mentioned by Chen et al. (2024) and Nepal and Jenkins (2011), the most frequently adopted in engineering study programs include active learning, experiential learning, alongside problem-, project-, case-, and inquiry-based learning models and communities of practice. Such methodologies foster the long-term retention of technical expertise required from engineering professionals, while simulta-

neously cultivating transversal competencies through collaborative teamwork and the resolution of authentic, real-world challenges (Hall et al., 2002; Richter & Kjellgren, 2024).

According to Chen et al. (2024), in a systematic review of 116 articles about pedagogical development in higher engineering education, these approaches are applied during training programs, with three typical durations: short-term, academic semester-based, and long-term. They are organized at three different practice levels, involving only one institution, several local institutions or institutions from several countries. According to the same source, most of the efforts in developing and applying innovative educational methods were carried out in the United States, followed by India, Denmark and Chile. The authors further note that, to date, relatively limited progress has been achieved in Europe. In this context, the present article aims to contribute to these findings by exploring the implementation of BIPs as an effective framework for short-term engineering training within the European Higher Education Area.

The COVID-19 pandemic also represented a decisive milestone in the evolution of pedagogical strategies, as it required the swift implementation of digital instructional modalities (Maladzhi & Kanakana-Katumba, 2020). Beyond the immediate crisis response, this period highlighted the transformative potential and versatility of hybrid learning frameworks. Blended Intensive Programs embody this shift by integrating international collaboration with hybrid learning structures (Unite! University Network for Innovation, Technology and Engineering, 2026). They serve as a testing ground for active learning strategies aimed at strengthening technical knowledge. The BIP 'Towards Enhanced Pedestrian Safety' emerges from this context. Its underlying design, pedagogical strategies, implementation and assessment phases are critically examined in the following sections, considering the EPIC framework (Consórcio EPIC, 2024).

3. Methodology

This study is grounded in an applied case study design in higher education, supported by a mixed-methods approach integrating quantitative and qualitative data from a sample of 25 participants across different academic levels. Data collection includes performance-based assessment (tests and project evaluation), structured surveys administered before and after the program, and qualitative participant feedback. Data analysis combines quantitative analysis of performance results, descriptive analysis of survey responses, and qualitative interpretation of participants' feedback. The following subsections describe the pedagogical design, implementation, and assessment processes through which these data were generated.

3.1. Pedagogical Approach

The pedagogical approach provides the contextual foundation of the case study, defining the guiding principles, structural organization, and learning environment underlying the design and implementation of the educational intervention.

In this context, the BIP 'Towards Enhanced Pedestrian Safety', developed within the Erasmus+ program, was coordinated by the University of Beira Interior (UBI), Portugal, in close collaboration with four international Higher Education Institution partners (HEIs): the University of Maribor (Slovenia), Bydgoszcz University of Science and Technology (Poland), the University of Rijeka (Croatia), and Helena Chodkowska University of Technology and Economics (Poland).

The pedagogical design of this BIP was strategically aligned with the EPIC Consortium framework and EPIC Principles for Higher Education (Ang & Domingo, 2025; Consórcio EPIC, 2024), which serve as the cornerstones of its innovative approach.

EPIC methodology is structured around four fundamental pillars: Embedded Learning (Student-centered), Pluralism and Inclusion; Internationalization and Connectivity (Networked Learning) and Digital Transformation and Learning Environments.

In the BIP 'Towards Enhanced Pedestrian Safety', student-centered learning was achieved by involving participants in the co-creation of knowledge (Bovill, 2020). Collaborative group projects, based on real-world scenarios, ensured active engagement, and the inclusion of diverse academic levels (Bachelor's, Master's, and Doctoral) alongside lifelong learning participants allowed dynamic peer-to-peer mentoring. Mixed, multicultural teams were tasked with the critical evaluation of problems and procedures, fostering autonomy, critical thinking, and leadership skills within a professional-simulated environment.

To ensure a Pluralistic environment, the BIP was designed to be accessible across different age groups and academic backgrounds. The pedagogical strategies were adapted to accommodate various student profiles (Hockings, 2010), promoting an intercultural atmosphere where diversity is seen as a driver for collaborative learning. This focus on accessibility ensures that the intensive component remains inclusive for all participants regardless of their previous experience.

By its very nature, BIP functions as a Networked practice that effectively bridges the gap between academic environments and broader societal stakeholders (European Commission, 2021). The collaboration between international partner universities fostered a transnational teaching-learning experience. This connectivity was further enhanced by the participation of non-academic experts during the virtual component (Lavanga, 2024). By using real-world data and local case studies to address the BIP's core topic (pedestrian safety), the program directly links academic research with social well-being and the pressing needs of urban communities (Sharma & Dehalwar, 2025).

Finally, the methodology used a Digital Learning Environment (DLE) to facilitate smooth collaboration. The integration of Virtual Learning Environment (VLE), combined with the application of digital tools for data collection, processing and analysis, shows a commitment to digital transformation (Alenezi, 2021). This technological integration ensures that students are not only learning about the BIP topic but are also mastering the digital tools essential for modern engineering and scientific research (Gürdür Broo et al., 2022).

In alignment with these four pillars, the program was designed as a high-quality, intensive learning experience to address the critical need for incorporating advanced safety and sustainability measures into civil and transport engineering education, with a special focus on pedestrian safety. Ultimately, the initiative sought to integrate technical knowledge with intercultural collaboration to generate innovative solutions for pedestrian safety challenges. This effort directly aligns with the United Nations Sustainable Development Goals SDG 3 and SDG 11.

3.2. Program Design

Within the context of the case study, the program design builds on the pedagogical framework by defining learning objectives, structuring activities, and aligning assessment strategies. Specifically, the design of the BIP followed an outcome-based approach grounded in the principle of constructive alignment, ensuring coherence between learning outcomes, teaching and learning strategies, and assessment methods (Biggs & Tang, 2011). The learning outcomes were defined to integrate both technical competences, such as road safety analysis and data-driven modelling, and transversal skills, including teamwork, communication, and intercultural collaboration. These outcomes informed the selection of content, structured around real-world case studies, and the adoption of active learning strategies, particularly collaborative project-based activities in an international and hybrid setting. Assessment methods combined performance evaluation, group project outputs,

and continuous feedback mechanisms, allowing for a comprehensive evaluation of student learning in alignment with the intended outcomes. The short-term and intensive nature of the BIP format further guided the integration of digital tools and data analysis resources, ensuring a coherent, practice-oriented, and context-responsive learning experience.

The BIP was structured to deliver a 3-ECTS credit workload, translated into a total student effort of 84 h. This workload was divided into 42 contact hours (blended physical and virtual) and 42 h of dedicated student self-study work (Figure 1).

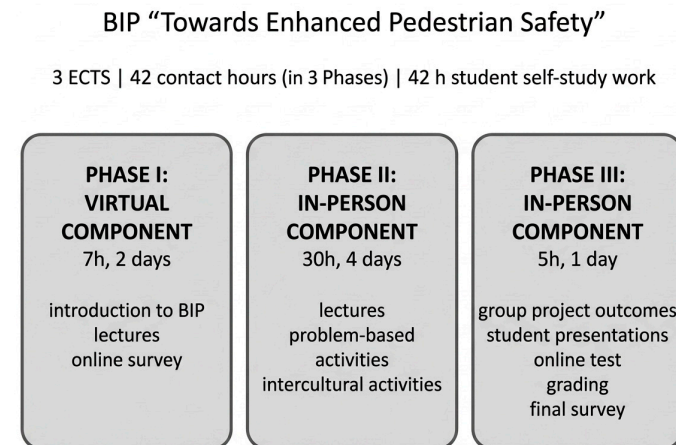


Figure 1. Three-phase structure of the BIP contact hours.

The program adopted a mandatory hybrid model, combining online preparation with an intensive in-person component. This approach ensured flexibility and comprehensive engagement, while maximizing the benefits of transnational collaboration within a short period of time.

Figure 1 presents the overall structure of the BIP contact hours, organized into three sequential phases: virtual, in-person, and assessment, designed to support a coherent progression from theoretical foundations to applied problem-solving and assessment.

This phased structure ensured a clear learning progression, beginning with theoretical foundations and culminating in applied practice. The hybrid format maximized accessibility and engagement, while the integration of cultural activities enhanced intercultural competence and teamwork.

3.3. Pedagogical and Learning Strategies

The pedagogical approach centered on active learning strategies designed to enhance student engagement, foster critical thinking, and promote collaborative knowledge construction. PBL was the primary methodology, enabling students to work with authentic urban safety scenarios and develop evidence-based intervention strategies. Complementary strategies included structured brainstorming, simulation exercises, guided debates, and iterative feedback rounds. Teams were purposefully designed to be heterogeneous, integrating different study cycles and nationalities while maintaining gender representation across all groups, notwithstanding the larger proportion of female students in the cohort. Group activities encouraged critical thinking, creativity, and teamwork, while structured brainstorming sessions facilitated the generation of innovative solutions. This not only enriched the analytical process through multiple perspectives but also developed transversal competencies such as communication, intercultural negotiation, teamwork, and leadership, skills increasingly essential for modern engineering professionals.

Digital technologies were fully integrated into the learning process. Students were introduced to: Geoinformation and Geographic Information Systems (ArcGIS Pro 3.5.2)

to process and interpret spatial data; software for machine learning-based classification tasks and data mining (WEKA 3.8.6); and video analysis tools to extract behavioral metrics such as crossing time and gap acceptance. The integration of these digital tools reflects the broader transformation of engineering practice toward data-driven and technology-enhanced approaches, as highlighted in the literature review (Skaug et al., 2025; Mustapha et al., 2024).

The digital learning environment was supported by the integration of various platforms: cloud storage (OneDrive), online survey tools (Google Forms), and cloud-based videoconferencing and collaboration software (Zoom 6.5.3). These tools were used for communication, resource sharing, and assessment delivery. Additionally, gamification elements were intentionally embedded within the initial online assessment to enhance motivation and promote early engagement, primarily using interactive presentation software (AhaSlides).

The program also benefited from guest lectures delivered by academic experts and professionals from transport and safety agencies and technology companies, strengthening the link between theoretical learning and real-world practice. The academic exchange was facilitated entirely through the English language.

In summary, key strategies included PBL, Collaborative Group Work, Gamification, and Integration of Digital Tools and Platforms. Active learning and PBL foster deep understanding and retention of knowledge, while digital integration enabled the development of advanced technical skills among students. Collaborative and gamified strategies enhance motivation and promote intercultural competence, preparing students for real-world professional challenges.

3.4. Implementation

The implementation phase outlines how the program was delivered in practice, providing the context for learning activities and subsequent data collection. In this regard, the BIP successfully engaged a diverse cohort of 25 participants, including Erasmus+ mobility students, local UBI students, and lifelong learners. This cohort spanned multiple academic levels, from final-year undergraduate (bachelor) to master's and doctoral levels, fostering a rich multidisciplinary, multilevel and multicultural learning environment. The program was supported by a robust and experienced team, including 7 academic staff and road safety auditors drawn from the five involved partner universities. Crucially, the program was enriched by the participation of 6 external keynote speakers. These non-academic contributors provided essential, real-world perspectives, representing key stakeholders in road safety.

To ensure coherent progression from theoretical foundations to practical application and evaluation, the implementation of the BIP was organized, as outlined above, into three distinct phases in accordance with European Commission directives (European Commission, 2025; Jager, 2025; Minerva et al., 2024; O'Dowd & Werner, 2024): virtual, in-person and evaluation.

3.4.1. Virtual Phase

Delivered over two days (7 h), the virtual phase initiated the BIP and facilitated early interaction between participants, partner institutions, and real-world practitioners. The first session comprised institutional introductions, a presentation of the program structure, 2 external speakers and an interactive online survey to capture participants' expectations and prior knowledge. This enabled the teachers to adapt subsequent activities to suit the group. The second session included non-academic expert lectures on national and metropolitan pedestrian safety challenges, active road safety technologies, and traffic signal

control systems for pedestrian crossings. These lectures offered a comparative perspective on pedestrian safety challenges in various European contexts.

The virtual phase ensured inclusivity, flexibility, and early engagement, enabling participants to actively contribute regardless of their geographical location. It established a common knowledge base and promoted initial interaction among students and staff, facilitating smoother collaboration during the in-person phase and ensuring continuity in learning progression.

3.4.2. In-Person Phase

The in-person phase formed the core of the program and was conducted over four consecutive days, totaling 30 h. The daily schedule balanced theoretical input with active learning (Hildebrandt et al., 2025).

During the intensive on-site week, participants engaged in a structured program combining expert lectures, collaborative group work, field-based activities and cultural engagement. All of these were focused on pedestrian safety within the context of civil and transport engineering.

Initial sessions addressed the technical design of pedestrian facilities and the implementation of safety-enhancing measures within urban networks, covering key topics such as infrastructure components, collision mechanisms, perception and visibility, and how to use citizen science to identify and address pedestrian-related safety issues. These theoretical inputs were complemented by interdisciplinary group activities in which students collaboratively analyzed real-world problems and developed preliminary design and assessment solutions.

Subsequent sessions focused on pedestrian crossing safety, covering speed control strategies, national design guidelines and the role of lighting in improving visibility and safety at crossings. These topics were reinforced through mixed-institution and mixed-gender group work, which enabled students to compare design practices across countries and evaluate their effectiveness critically.

The program also addressed pedestrian environment quality and walkability, introducing methods for evaluating pedestrian conditions in urban and rural areas, including spatial analysis techniques. Theory and empirical research were used to examine human behavior in relation to pedestrian safety, with a particular focus on crossing behavior, reaction times, vulnerable user groups such as children and the elderly, and advanced behavioral analysis methods such as eye tracking.

In addition, the week featured a significant emphasis on data-driven safety assessments, equipping participants with the tools to perform objective evaluations of urban pedestrian safety. Participants were introduced to national accident databases from multiple countries, as well as methods for analyzing pedestrian accident data. This was followed by sessions on emerging technologies for analyzing pedestrian accidents, such as using video footage, GIS-based methods and machine learning approaches to evaluate the safety of pedestrian crossings, model pedestrian severity and identify risk factors.

The program also incorporated a structured set of cultural and social activities designed to encourage intercultural interaction and support the development of team-building skills in a multicultural environment. Participants explored the region's historical legacy through visits to the Wool and City Museums, while a guided tour of local urban art provided a modern perspective on the city's cultural landscape. The program also featured a farewell dinner showcasing regional and national cuisine, complemented by an academic artistic activity rooted in Portuguese university tradition.

This intensive, face-to-face format promoted active engagement and hands-on learning. Combining technical sessions with cultural activities enriched the educational experience,

fostering academic and intercultural competencies. The collaborative structure encouraged teamwork and problem-solving in a real-world context.

3.4.3. Assessment Phase

The assessment phase plays a central role in the mixed-methods approach, providing both quantitative and qualitative data for the evaluation of the pedagogical framework.

The final phase lasted approximately 5 h (1 day) and was dedicated to qualitative and formal assessment to ensure robust evaluation of both individual competence and collaborative skills.

Assessment of students was conducted using a combination of summative, formative and qualitative indicators. Summative assessment comprised the group project report and presentation (80% of the final grade) and the individual test (20%), ensuring alignment with learning outcomes relating to theoretical framework, problem formulation, data analysis and solution development and communication. Formative assessment took place throughout the practical sessions, during which lecturers provided continuous feedback to support the iterative improvement of methodologies, data interpretation and project structuring. Finally, qualitative assessment was based on pre- and post-program surveys that addressed students' expectations, their perceptions of learning, their intercultural experiences, their digital literacy, and their self-assessed proficiency in soft skills such as teamwork, communication, and intercultural collaboration.

The individual component of the summative assessment, administered via Google Forms, evaluated students' theoretical knowledge and digital competencies. During the collaborative project preparation, students engaged in structured internal discussions to define their proposed solutions. The projects were evaluated based on methodological rigor, technical validity, clarity of presentation and practical feasibility. The final work presentation was a pivotal learning experience, enhancing students' communication and negotiation skills while strengthening their ability to articulate complex technical content in English.

The subsequent discussion with the evaluation panel offered a crucial opportunity to develop argumentation skills. Students were required to justify their methodological choices, defend their proposals through evidence-based reasoning, and respond effectively to critical questions. The question-and-answer approach demonstrated the students' capacity for active listening and engagement with both the jury and their peers. These cross-group discussions allowed participants to exchange perspectives and evaluate alternative approaches, fostering a culture of peer-led reflection. Ultimately, the ability to assimilate external critique into their final conclusions emerged as a key outcome, reinforcing professional communication and collaborative competence in engineering contexts.

This dual evaluation strategy balanced individual accountability with collaborative performance, providing a comprehensive assessment of technical knowledge and soft skills. Immediate feedback supported reflective learning and continuous improvement. Concerning the qualitative assessment, results revealed clear improvements in technical knowledge, digital competencies and motivation for interdisciplinary and international collaboration.

4. Results and Discussion

This section discusses the outcomes of the BIP's implementation, detailing the results of the collaborative project conducted in Covilhã, the quantifiable student learning achievements, and a comprehensive analysis of the participants' feedback regarding the pedagogical process.

To ensure participant privacy, the study strictly adhered to anonymity protocols. Where necessary, faces were blurred to protect participant identities, and all analyzed

data are presented in aggregated form to prevent any direct or indirect identification of individuals, in accordance with ethical standards.

4.1. Collaborative Project

The project assignment the students received (improving traffic safety on a designated section of the road network in Covilhã) represented a real-world problem. The goal was for students to recognize risk factors in real traffic conditions and to offer solutions that include innovative and well-founded solutions for improving traffic safety through construction and traffic measures. As previously noted, students were organized into heterogeneous teams, ensuring a diverse mix of backgrounds, academic levels, genders, and nationalities.

The structure of the practical task led all teams through the same problem-solving steps for the assignment: analysis of the existing traffic and traffic safety situation (on-site) and development of traffic and infrastructural solutions to improve traffic safety. All groups performed on-site assessments by collecting data and observing the local context. Although their primary focus varied depending on each team's predominant background, all groups ultimately conducted comprehensive analyses of the traffic conditions, infrastructural elements, and the social environment of the study area. This phase also allowed students to compare engineering practices in Portugal with those of their home countries.

Students planned the research on the assigned road network sections through discussion in teams before going out to the street network. Their task in preparing the fieldwork was to apply an engineering approach to determine how to efficiently collect data while considering the resources at their disposal, the size of the area under analysis, the time available, the equipment, and the number of team members. Since not all students had the same experience with fieldwork, teamwork and communication were crucial in this phase. They helped students efficiently collect real-world data in an unknown environment within a limited timeframe.

The next task was to analyze the data collected and identify the problems (Figure 2). This part of the project was essential to proposing and developing solutions. The data describing the existing traffic situation and the observed inconsistencies and problems with the current traffic arrangements were an integral part of the final presentation of solutions.

After the students identified the main problems, they proceeded to propose improvement solutions. They analyzed these solutions from various perspectives, using the knowledge gained during their studies and introductory lectures, and presented them using different technologies. During the teamwork, it was noticeable that students recognized the specific knowledge of colleagues from other fields (transportation disciplines). Through the teacher's suggestions, students were directed to integrate the knowledge of all group members in their solutions, that is, to somehow overlap and sublimate solutions from different perspectives into the final solution. This approach sparked active discussions within the groups, prompting students to argue proposals from their own perspective and consider solutions from other disciplinary areas (integrated solutions).

While actively working in teams with colleagues from other EU countries, the students identified similarities in their problem-solving approaches as well as differences in technical regulations among the participating countries. As future engineers (transport or civil), it is essential for them to recognize that their solutions must comply with the regulations, guidelines, standards, or laws of the context in which they operate. Comparing how certain elements are regulated, in this case those related to the design of urban transport infrastructure from the perspective of pedestrian safety, proved to be an effective way for students to understand both the similarities and differences between individual local contexts.

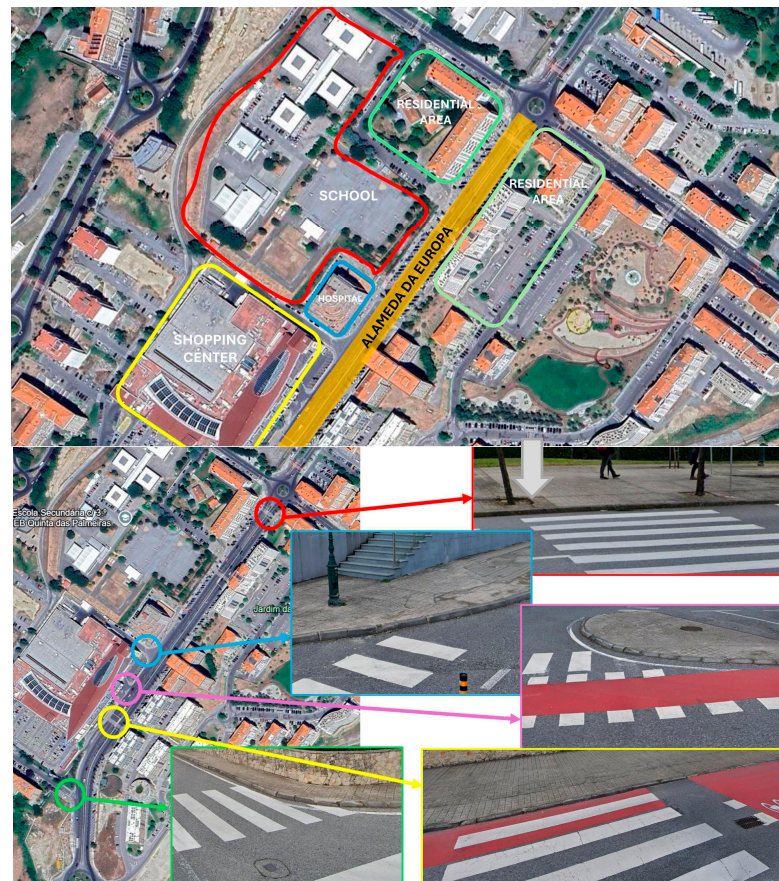


Figure 2. Mapped inventory and detail photos of crosswalks for identification of safety problems near Quinta das Palmeiras High School.

All participating teachers had the task of mentoring all four student groups simultaneously. In this way, it was ensured that every student could rely on the expert knowledge of all instructors whenever needed. In addition to formal classroom lectures, informal and flexible learning also took place, depending on the needs of each group, as students participating in the BIP are enrolled at different study levels.

For all steps in the analyses and interpretation of the results, as well as the presentation of the proposed solution, students used different digital tools as described in previous sections.

On the final day of the BIP, all teams delivered comprehensive presentations of their work, encompassing both the traffic safety analysis and their proposed infrastructural and operational improvements (Figure 3). The presentations, in English, were given in front of all other students and teachers, and all teams were required to actively participate. After the presentations, students engaged in a discussion in which they further elaborated their findings and shared ideas.

Notably, the resulting proposals developed were formally presented to the Municipality of Covilhã, bridging the gap between academic work and tangible societal impact by contributing directly to local policy discussions on pedestrian safety.

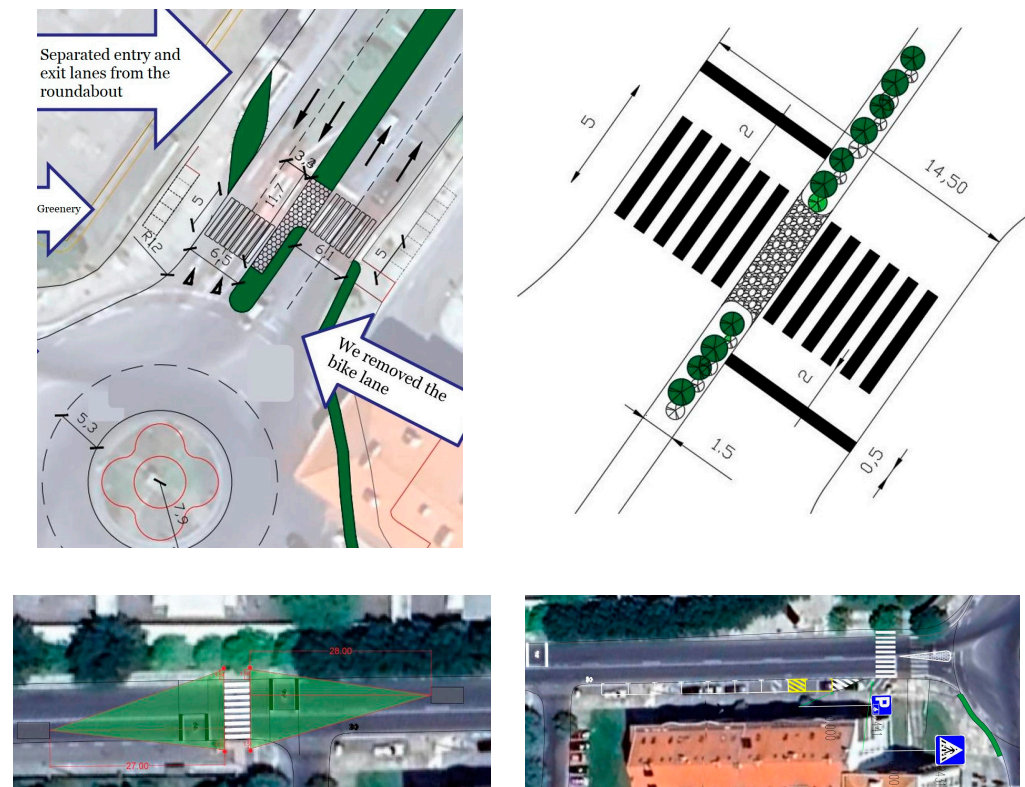


Figure 3. Overview of the infrastructure and traffic safety solutions proposed by groups.

4.2. Assessment of Students' Achievements

Student achievements were assessed through several evaluation metrics to ensure comprehensive coverage of all learning outcomes. Learning outcomes related to knowledge and defined in the BIP syllabus were evaluated through a test. The test was based on multiple-choice questions, and the questions were prepared by all teachers involved in BIP, based on the lectures they delivered during the in-person phase. The test accounted for 20% of the final grade.

The results presented in Figure 4 (left) indicate that students achieved test scores ranging from 80% to 100%. The success of solving the test depended largely on the students' level of study at their universities. Students involved in bachelor's studies had lower scores than those from master's and doctoral levels. Similar findings have been reported in engineering education studies, which highlight differentiated engagement patterns and learning outcomes across student levels in blended and active learning environments (e.g., Vodovozov et al., 2022).

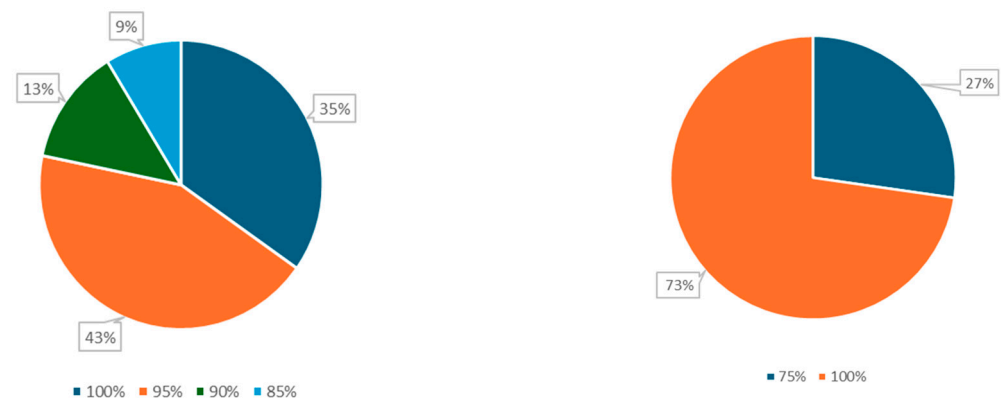


Figure 4. Students' achievements: multiple choice test (left) and collaborative project (right).

Collaborative projects represented the most important part of BIP's activities, as this form of student engagement facilitated the acquisition of all important intended learning outcomes: identification and analysis of real pedestrian safety problems, application of problem-solving procedures and use of digital tools for safety analyses. Also, collaborative projects were crucial for the enhancement of transversal skills such as teamwork, leadership, communication and intercultural sensitivity. For this reason, collaborative project activities were weighted at 80% of the total BIP assessment. The project assessment was structured around the key stages of implementation: field data collection, data analysis, the quality of the proposed solutions, and the final presentation, including the students' active participation in the subsequent discussion. All team members who participated in all phases of the project received the same grade. As shown in Figure 4 (right), 73% of participants demonstrated strong assimilation and application of knowledge, achieving a perfect score (100%) in this component. Some students did not attend the final presentation, which is why they did not receive part of the points (75%).

This strong performance in collaborative tasks further supports the role of experiential and problem-based learning in engineering education, which has been identified as a key component of Engineering Education 4.0. As highlighted in the literature review, such approaches are particularly effective in fostering both technical competences and transversal skills, including teamwork, communication, and critical thinking, which are essential for modern engineering practice (Chen et al., 2024; Nepal & Jenkins, 2011).

The percentages from the test and the collaborative project were converted into a final scale of 20 points. Students achieved scores ranging from 15 to 20 points, demonstrating that all participants successfully mastered the program.

These results are consistent with the shift from traditional lecture-based approaches toward active and student-centered learning models, as discussed in Section 2. In particular, the high levels of knowledge acquisition and performance observed in both the test and project components align with findings in the literature that active learning and problem-based approaches enhance retention and deep understanding of engineering concepts (Chen et al., 2024; Hall et al., 2002).

4.3. Students' Evaluation of the Process

To gather participant feedback on the BIP activities, students were surveyed on two separate occasions. The first survey was conducted immediately after the end of the two-day online activities in April 2025, and the second after the in-person activities in Portugal, in June 2025.

4.3.1. Survey on the Virtual Component

As part of the BIP, an online activity was held in April with the participation of 22 students from the 4 countries and 5 universities (Figure 5 (left)).

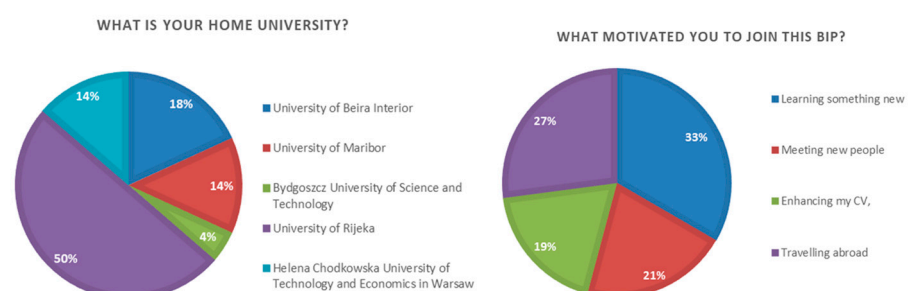


Figure 5. Distribution of participants by university (left) and primary motivations for attending the virtual component (right).

Five students (23%) had previously taken part in an Erasmus+ program, while only one student had experience with a Blended Intensive Program (BIP). The motivation for applying to this BIP varied but was mostly driven by the desire to travel and acquire new knowledge (Figure 5 (right)). After completing the virtual phase of the BIP, 32% of students expressed interest in future teamwork within the program, while for the others, this depended on the specific tasks ahead. Almost all students were to some extent (moderately to highly) familiar with the main theme of the BIP and showed the greatest interest in exploring new technologies for analyzing pedestrian infrastructure and safety (Figure 6).

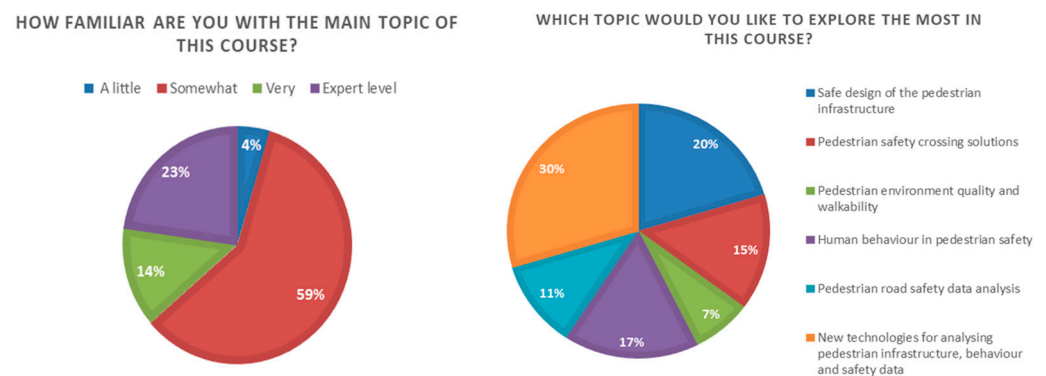


Figure 6. Distribution of participants by prior familiarity with the BIP topic (left) and preferred topics for exploration during the in-person mobility component (right).

In addition to teamwork, they expressed a desire to develop skills in communication, critical thinking, and creativity. These expectations are consistent with the evolving skill profile required of modern engineers, as discussed in Section 2, where the need for both technical expertise and transversal competences was emphasized (Alfar, 2025). The strong interest in collaborative and active learning formats observed in this study reinforces the relevance of such pedagogical strategies in addressing contemporary educational challenges.

Following the online sessions, among the various learning methods, students expressed the highest interest in group work (45%), further validating their strong motivation for teamwork (Figure 7).

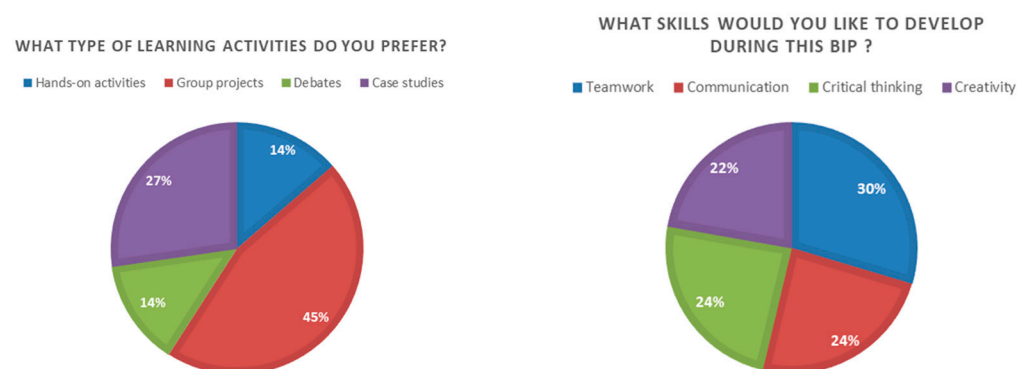


Figure 7. Distribution of preferred learning activities (left) and key skills to be developed during the BIP (right).

Since the BIP itself requires the involvement of at least three universities from different EU countries, all students confirmed proficiency in at least one foreign language (English) in addition to their native tongue, while 40% reported being competent in a second foreign language.

4.3.2. Survey on the In-Person Component and Overall Program Satisfaction

A final satisfaction survey was conducted a few days after the completion of in-person activities, through an online form. A total of 17 participants, comprising bachelor's, master's, and doctoral students, completed the survey, with master's students representing most of the cohort. As English proficiency was a prerequisite for the BIP, all students confirmed fluency in at least one foreign language at the start of the program. Following the in-person phase and continuous immersion in the language, most participants rated their English language skills as 'Good' or 'Very Good,' while a smaller group reported 'Excellent' proficiency. These results align with the students' initial motivations; beyond the desire to travel, network, and gain knowledge, improving English language skills was a primary driver for applying to the program.

The preliminary information about the program was considered adequate and sufficient by students (94%), and the communication and support from the organizing team before and during the program was rated as excellent (88%) (Figure 8).

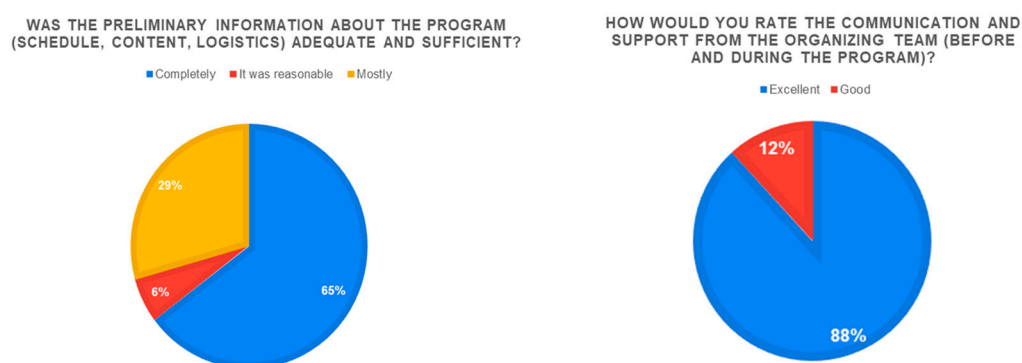


Figure 8. Student assessment of preliminary program information and the quality of support provided by the organizing team.

As illustrated in Figure 9, 88% of the students confirmed that the BIP's objectives were clearly defined. Furthermore, more than 71% found the content highly relevant to their own learning goals.

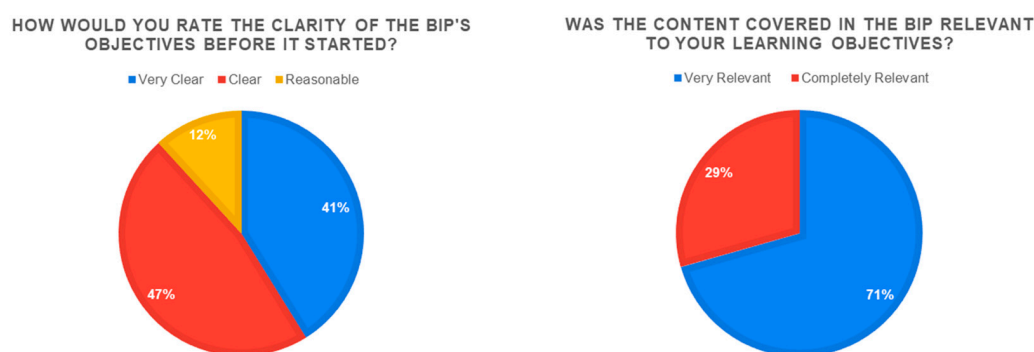


Figure 9. Participant assessment of the clarity of program objectives and the alignment of content with individual learning objectives.

Although the quality of activities within the online sessions was rated excellent by more than 50% of students, in-person activities resulted in even greater satisfaction (more than 70%), and overall experience in this BIP was rated as very satisfied by 76% of responders (Figure 10).

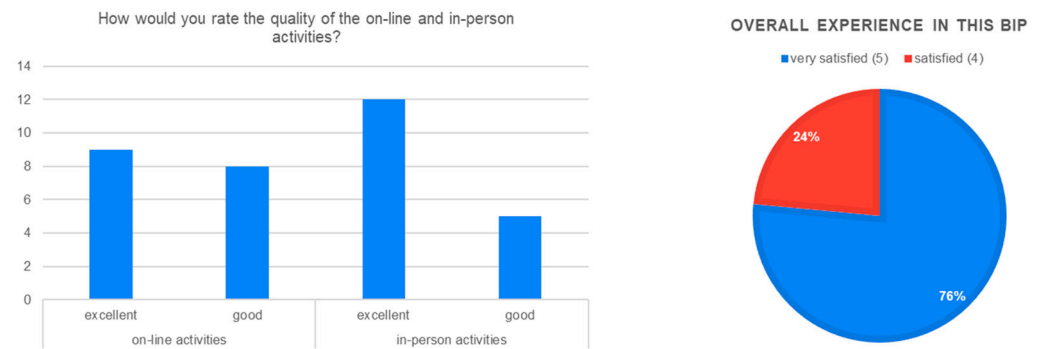


Figure 10. Comparative satisfaction levels between virtual and in-person activities and overall program rating.

Students confirmed that this way of acquiring new knowledge and learning outcomes encouraged collaboration and interaction among the participants, resulting not only in the acquisition of new knowledge but also in the development of new skills.

These high levels of satisfaction and engagement reported by participants are consistent with previous studies on hybrid and blended learning environments, which highlight their potential to enhance student motivation and interaction when combined with active learning strategies (Nortvig et al., 2018; Maladzhi & Kanakana-Katumba, 2020).

Moreover, the international and collaborative nature of the BIP aligns with current trends in engineering education that emphasize global learning environments and intercultural competence development as key components of professional training (Richter & Kjellgren, 2024).

Taken together, these findings provide empirical support for the suitability of the EPIC-based pedagogical approach in the design and implementation of BIPs. In particular, the positive outcomes observed in terms of engagement, collaboration, and competence development reflect the core principles of the EPIC framework and reinforce its applicability to short-term, hybrid, and international learning formats, despite not having been originally conceived for such contexts.

In conclusion, the high levels of student satisfaction are evident, with 82% stating they would likely recommend the experience to their peers and 88% expressing a strong desire to participate in similar BIPs again.

5. Conclusions

5.1. Main Findings and Limitations

This study demonstrated the effectiveness of the BIP-TEPS in integrating digital tools, problem-based learning, and intercultural collaboration to foster both technical and transversal competences in advanced civil engineering education. The program successfully bridged the gap between theoretical engineering principles and real-world urban safety challenges by engaging students in authentic, data-driven analysis of real environments and requiring them to co-create solutions for concrete pedestrian safety problems. This approach aligns learning outcomes with the evolving demands of Engineering Education 4.0 and the Sustainable Development Goals 3 and 11, reinforcing the relevance of engineering education for addressing complex societal challenges.

The structured three-phase hybrid design ensured a clear and progressive learning pathway, beginning with foundational concepts in the virtual component and culminating in practical, field-based application and collaborative project work. The integration of qualitative, formative and summative assessment methods, including tests, project evaluation, and student self-assessment, indicates that participants achieved a high level of mastery of the intended learning outcomes.

The systematic use of project-based learning and collaborative approaches, supported by a multidisciplinary and international teaching team, strengthened the alignment between learning outcomes, activities, and assessment. This pedagogical configuration contributed not only to technical knowledge acquisition but also to the development of transversal competences such as teamwork, communication, leadership, and intercultural sensitivity, particularly within heterogeneous and multicultural student groups.

Importantly, the findings confirm the adequacy of the EPIC framework in this context. Although EPIC was not originally designed specifically for short-term and intensive formats such as BIPs, the results demonstrate its adaptability and effectiveness when applied to hybrid, international, and practice-oriented learning environments. This directly supports the main objective of the study, providing empirical evidence of the applicability of EPIC in emerging educational formats.

The positive evaluation results, including high levels of student satisfaction regarding objectives, content relevance, support quality, and overall experience, further reinforce the effectiveness of the program. In addition, the strong alignment between students' motivations, such as international exposure, networking, and language development, and their reported experiences highlights the added value of BIPs as an innovative learning format within higher education.

Despite these results, several limitations should be acknowledged. First, the study is based on a single case study with a specific thematic focus and a limited sample size, which may restrict the generalisability of the findings. Second, although the evaluation included performance-based components (e.g., tests and project outputs), part of the analysis relied on self-reported data, introducing potential subjectivity. Third, the short-term nature of the BIP limits the assessment of long-term learning outcomes and competence retention. Finally, the absence of a comparative framework or control group prevents a direct evaluation of the relative effectiveness of the EPIC approach compared to alternative pedagogical models.

The implementation process also highlighted practical challenges, including coordination across institutions, balancing partner contributions, managing heterogeneous student profiles, and addressing initial language barriers. These aspects underline the importance of careful pedagogical planning, institutional alignment, and inclusive teaching strategies in international and hybrid learning contexts.

5.2. Future Research Directions

The limitations identified in this study suggest several relevant directions for future research. First, to address the limited generalisability of the findings, further studies should apply the EPIC framework across multiple BIPs and different engineering domains, enabling comparative and multi-case analyses.

Second, although the evaluation included performance-based components, future work could adopt more comprehensive mixed-methods approaches by combining perception-based instruments with additional objective performance indicators and learning analytics, in order to strengthen the robustness of learning assessment.

Third, longitudinal studies are needed to assess the persistence and transferability of competences developed in short-term intensive formats, particularly transversal skills such as teamwork, communication, and intercultural collaboration.

Additionally, future research should explore the relative effectiveness of BIPs compared to other pedagogical approaches, including traditional and longer-term active learning models, to better understand the specific added value of short-term hybrid formats.

Finally, further work could refine the application of the EPIC framework to BIPs, including the development of design and evaluation approaches tailored to short-term and hybrid international learning settings. It would also be relevant to investigate the role of

BIPs as platforms for co-designing curricula and micro-credentials within European university alliances, supporting a more integrated and collaborative Higher Education Area.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Beira Interior. It is also evident that the images contained in the manuscript were anonymised and reviewed by the University’s Data Protection Officer (DPO).

Informed Consent Statement: Participant consent was integrated into the institutional framework of the Erasmus+ Blended Intensive Program (BIP), where participants were informed that educational activities and their outcomes could be used for academic and dissemination purposes. To ensure the highest ethical standards and protect participant privacy, the authors have implemented full anonymity protocols. All data are presented in an aggregated format, and professional visual anonymization (blurring of faces) has been applied to all photographs to ensure that no individual can be identified.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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Abbreviations

The following abbreviations are used in this manuscript:

BIP	Blended Intensive Program
TEPS	Towards Enhanced Pedestrian Safety
GIS	Geographic Information Systems
SDG	Sustainable Development Goals
EPIC	Embedded, Pluralistic, Internationalized and Connected
PBL	Problem-Based Learning
ITS	Intelligent Transportation Systems

C-ITS	Cooperative Intelligent Transportation Systems
EE	Engineering Education
UBI	University of Beira Interior
ECTS	European Credit Transfer and Accumulation System

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