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RESEARCH ARTICLE

Bridging Learning and International Practice for Enhancing Physics Education

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ABSTRACT

This paper discusses the implementation and outcomes of an Erasmus+ Blended Intensive Program (BIP) focused on physics education. The program aimed to address the challenges faced by first-year engineering students in mastering physics through a combination of online and face-to-face phases. Participants included students and faculty from three European universities: the Hungarian University of Agriculture and Life Sciences (MATE), the Universitat Politècnica de València (UPV), and the Slovak University of Agriculture in Nitra (SUA). A survey was proposed to students to obtain information that would benefit future programs. Survey results revealed significant improvements in students' social skills and a high level of satisfaction with the program's organization and methodology. However, areas for improvement were identified, particularly in administrative processes. The study highlights the importance of international cooperation and collaboration frameworks to ensure the program's effectiveness across diverse educational systems. Overall, the BIP provided a valuable educational experience that enhanced students' theoretical knowledge, practical skills, and interpersonal abilities, demonstrating the benefits of integrating innovative teaching methods in higher education.

Keywords: Blended intensive program, international cooperation, physics, student skills development.

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1. Introduction

Physics subjects are included in the curricular contents of the different Engineering Bachelor's Degrees as a part of the basic training of students, with the aim of providing them with the necessary prior knowledge to address technical subjects in subsequent courses.

However, learning Physics requires both a solid knowledge of the theory and practical skills in the laboratory, where the behaviour of the theoretical models studied in the classroom is analysed in detail. This is particularly complex for students of degrees such as Agricultural or Environmental Engineering, and especially among first-year students. Several factors explain this complexity, such as the heterogeneity in the level of knowledge with which students access university or the difficulty posed by large groups, among others (Assem *et al.*, 2023; Bozzi *et al.*, 2021; Briggs, 2020). Therefore, there is a relatively frequent lack of motivation and drop-out rates, being necessary to activate strategies that make physics more accessible and attractive to students.

In this sense, different studies can be found in the literature, proposing methodologies or activities that promote academic performance and contribute to increasing interest in the discipline, such as flip teaching (Gómez-Tejedor *et al.*, 2020), augmented reality technology (Vidak *et al.*, 2024), virtual laboratories (Asencios-Trujillo *et al.*, 2024), or peer learning activities (Bozzi *et al.*, 2021). Another action that can be motivating, since it encourages student involvement in the subject, is participation in an Erasmus+ Blended Intensive Program (Erasmus+ 2021–2027; European Commission, n.d.). In this activity, students work in teams, first developing a period of online work and then a face-to-face stage in which all of them travel to the country of the host university for short physical mobility (between 5 and 30 days). This type of experience has been developed successfully in some settings in the context of higher education, as described in Gögele and Kletzenbauer (2023) and Laura *et al.* (2023), and it is an alternative educational experience that can enrich and enhance the teaching and learning process blending online and onsite education.

This paper presents one learning experience initiative on the topic of physics carried out in the framework of an Erasmus+ Blended Intensive Program (BIP). The idea of undertaking this program arose when the professors from the universities involved in the consortium verified that their students had similar shortcomings and difficulties: students in their first academic year, who take basic subjects, and who are not yet eligible for a long-term Erasmus stay.

The project developed within the framework of the Erasmus+ BIP, called *Physics without Borders*, was hosted by the Hungarian University of Agriculture and Life Sciences (MATE, from the Hungarian *Magyar Agrár-és Élettudományi Egyetem*). It was organized by the Department of Physics of the Institute of Mathematics and Basic Science. It was implemented with two additional partners: on the one hand the Universitat Politècnica de València (UPV), Spain, from the Department of Applied Physics, and on the other, the Slovak University of Agriculture in Nitra (SUA), Slovakia, from the Institute of Electrical Engineering, Automation, Informatics, and Physics.

The participants of this project consisted of 12 MATE students, 15 UPV students, and 5 SUA students, totalling 20 students in addition to the professors from the three countries. The different student teams, confirmed as detailed below, started working in February 2023, the online seminars took place in June 2023, and the mobility week in April 2024 (from 1–5 April). After the face-to-face stage, a questionnaire was addressed to the students to give their opinions on different aspects of their experience. At the end of the program, the students were awarded 3 ECTS (European Credit Transfer System) credits.

2. Methodology

2.1. Teaching Program Development

This type of program requires prior coordination before the distribution of online work to align pedagogical objectives and methodologies with the peculiarities of each participating institution. The diversity in the educational frameworks of European universities, although enriching for the program, poses significant challenges. Differences in curricula, credits, and assessment requirements can affect the cohesion and effectiveness of the program. It is imperative to establish a common framework for collaboration that respects the autonomy of each university while ensuring that students achieve the expected learning outcomes. This requires detailed planning and continuous communication among all parties involved to ensure that the online component of the BIP is not only accessible and flexible but also consistent and equitable within the context of the European higher education area.

The BIP program consists of two phases. An online phase with synchronous and asynchronous work and a second exchange phase in which participants travel to the host university to present their work and exchange knowledge through seminars. In this case study, the final work presented was the complete development of a laboratory practice, from developing the theoretical framework to its results and conclusions.

Firstly, the students were divided into several groups of three students each. Each group was assigned to a tutor professor. The students began by reviewing the essential theoretical principles underpinning the experiments to be carried out. This review included concepts of thermodynamics, electrokinetics, and electromagnetism, following the specific learning objectives of the course. The course materials, accessible through the learning platform (Sakai), provided the theoretical foundations students could consult asynchronously to build a solid base before proceeding to the experimental phase.

Next, the practice methodology was articulated in weekly work packages, where the experiments were designed and planned. These packages included study guides, experiment specifications, and checklists to ensure that all theoretical and practical aspects were understood and applied correctly. Finally, the results were analysed after the collection and processing of data. The phase concluded with detailed reports where each group presented their results, demonstrating their ability to apply theory to practice. They were asked to finish with conclusions in their reports, where they critically evaluated the results obtained, discussing possible errors, limitations, and areas for improvement for future experiments. This asynchronous and tutored phase meets the course's learning outcomes and fosters essential skills such as critical thinking, time management, effective collaboration, and the practical application of theoretical knowledge.

2.2. Survey Design

When designing surveys for programs like BIP, it is crucial to integrate quantitative and qualitative methods to capture a full spectrum of data and perspectives. This mixed approach allows not only for the precise measurement of the impact of the program on our students (quantitative) but also for understanding the nuances behind these data (qualitative) (Greene *et al*., 2005). In a hybrid program such as the BIP, collecting evidence of results is very important, and both types of data must be collected and synthesized (Dixon-Woods *et al*., 2005). This is due to the high participation of different organizations in the development of the program in which students and faculty from different teaching units of other universities are mixed.

For designing our survey, we considered several steps. First, identifying the purpose of the study is essential to guide all subsequent stages of design. Secondly, the combination of closed-ended and open-ended questions in a survey facilitates the collection of quantitative and qualitative data. Closed-ended questions allow for statistical analysis, while open-ended questions provide deep qualitative insights into participants' motivations and opinions. In addition, it is essential to test the survey before distribution to ensure clarity and avoid bias. Our study combined open-ended responses, Likert scale-based (Joshi *et al*., 2015) response questions, and closed-ended responses with outcome selection.

The survey was implemented using the *Forms* software, part of the *Microsoft Office* automation package. This software allows for collaboration during design and has a

responsible design. Therefore, this ensures that the website automatically adjusts to fit the screen size and orientation of the device being used to view it, providing an optimal browsing experience for all users, regardless of their device.

In summary, our survey had 15 questions. Six open-ended questions, two yes/no questions, two five-level Likert scale questions, two closed-ended questions, one with an open-ended subsection, and finally, one entirely open-ended question for other comments not included in the previous questions. The results were processed using spreadsheets and word clouds. A total of 23 survey responses were collected, read, and analysed in detail.

3. Results

3.1. Academic Results

As a final product, the learning outcome was the realization, presentation, and recording of learning objects. The students, after the process detailed above, managed to complete the full design of a laboratory practice with the description of the theoretical framework for its realization. During the period of stay at the MATE university, teaching experiences were conducted among the student groups. It is important to emphasize that the exchange of academic experiences was fruitful for students and teachers. In this way, interesting ideas were shared for implementation in the subjects of each university.

The learning objects developed by the Spanish teams are accessible and visible in the Institutional Repository of the Universitat Politècnica de València, Riunet, facilitating its visibility and ensuring its preservation. These learning materials are listed below and cited in more detail in the references section:

- Laboratory practice: Temperature measurement using a resistance temperature detector (RTD). http://hdl.handle.net/10251/196961.
- On the use of the Digital Oscilloscope. http://hdl.handle.net/10251/200164.
- Study of the process for charging and discharging a capacitor. http://hdl.handle.net/10251/200199.
- Characterization of a direct current generator and receptor. http://hdl.handle.net/10251/194266.
- Lab session 5: measuring the Earth's magnetic field. http://hdl.handle.net/10251/199028.

The Hungarian participants were preparing the next measurements with an English version description and the numerical evaluation of the measurements, as well:

- Hair thickness measurement by laser interference method,
- Measurement of the I-V characteristics of a photovoltaic module,
- Comparative measurement of the surface heat transfer coefficient in water and air by a Pt1000 thermal sensor,
- Measurement of the light conversion efficiency of different light sources (bulb, energy saving lamp, LED).

3.2. Survey Results

The responses to the survey were analysed by differentiating between those of the UPV and those of the MATE students. All UPV students answered the questionnaire with a total of 15 responses, while 8 students from the host university also participated, completing the total of 23 surveys mentioned above.

A first block of questions was proposed aimed at finding out if this program had helped students develop or enhance their interpersonal skills. First of all, regarding the question of whether the experience has helped them to improve their social skills, 93.3% of the Spanish students and 100% of the Hungarians answered affirmatively. Continuing with the soft skills analysis, they were asked if they had established bonds with people they might not have met in another context, and 93.3% of UPV students and 100% of MATE students answered positively. Finally, they were asked if this experience had allowed them to get to know their classmates better or to relate to others with whom they did not have such a close relationship. In this case, 100% of the students (both Spanish and Hungarian) answered affirmatively. These answers demonstrate these programs' success in developing personal and transversal skills in their academic training, which are vital in their education.

The second block of questions was intended to assess the development of the program itself from the point of view of organization, management, work methodology, etc. Firstly, students evaluated the program regarding work meetings, academic activities proposed by the host university, and the work proposed. The rating scale ranged from 1 to 5, with 5 being the best positive rating. An average value of 4.47 out of 5 was obtained among UPV students, compared to a very similar value of 4.75 among MATE students. 93.33% of those surveyed rated the program as between 4 and 5 points. Results are shown in Fig. 1.

This survey also aimed to assess the student's perception of the bureaucracy generated by this type of program. To do this, the students were asked again, giving them a five-level Likert scale, with 5 being the best positive rating.

In this case, notable differences were observed between the students' responses, depending on the university of origin. Regarding UPV students, an average value of 3.13 points was obtained, with 40.0% giving a rating between 4 and 5 points. It is also worth noting that 33.34% rated it

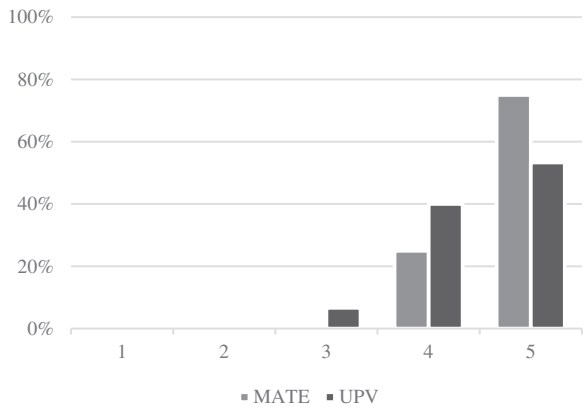

Fig. 1. Overall program rating on a Likert scale for UPV and MATE students.

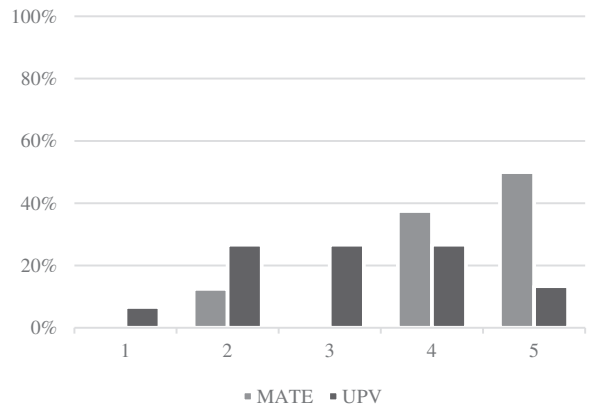

Fig. 2. Rating of program bureaucracy on a Likert scale for UPV and MATE students.

between 1 and 2 points, as shown in Fig. 2. However, in the case of MATE students, the average value was 4.25, much higher than the 3.13 given by the UPV students (Fig. 2).

Students were also asked about the main difficulties they faced during the development of the program. The options were funding issues, administrative problems, inconvenience with the academic calendar, and workload. 93.75% of UPV students answered that financing was the biggest problem they had encountered. These opinions contrasted with those of MATE students; 37% answered that the main problems had been administrative, while 25% highlighted both financing and academic calendar problems (Fig. 3).

When students were asked about the recommendations they would propose to improve future programs, their responses were divided into 4 blocks: Planning/Organization, Program Design, Collaboration with other universities, and Others, giving them the possibility of checking more than one response. 45.0% of the responses from UPV students felt that planning and organization should be improved, while 25.0% pointed out program design. Finally, MATE students referred to the need for collaboration between different universities (44.44%) and the improvement of program design (22.22%) (Fig. 4).

Concerning the open-ended questions, it is worth noting that most of the UPV students highlighted the importance of learning languages for their academic and professional future and that this program helped them to improve their level. On the other hand, they emphasized the importance of these programs for the motivation of first-year students.

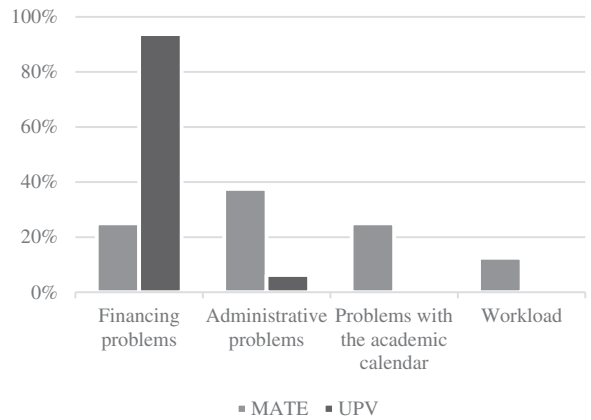

Fig. 3. Problems detected in the BIP program.

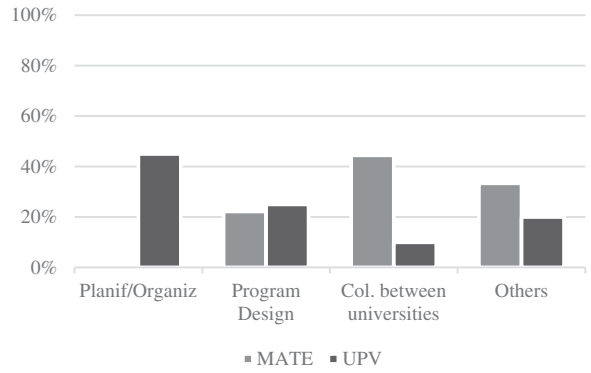

Fig. 4. Recommendations to improve BIP experience for UPV and MATE students.

Finally, MATE students answered by focusing attention on the repetition of the program at the UPV and on its relevance for their personal development.

4. Discussion

Implementing the Erasmus+ BIP program in the context of physics education has proven to be an effective tool for addressing various educational challenges. One of the most relevant aspects was improving students' social skills, as evidenced by the high percentage of positive survey responses. This suggests that integrating online and face-to-face phases facilitates the learning of technical content and promotes the development of essential transversal competencies for students' comprehensive education.

In terms of organization and methodology, the experience was positively valued by most participants. However, the results also indicate areas for improvement, particularly in the bureaucratic management of the program. The difference in the perception of bureaucracy between UPV and MATE students highlights the need to simplify and standardize administrative processes to improve the user experience. Despite these difficulties, effective coordination and continuous communication between institutions allowed the alignment of pedagogical objectives and ensured the program's coherence. This underscores the importance of a common collaboration framework that respects the autonomy of each university and ensures that students achieve the expected learning outcomes.

It should be noted that the students who went to Hungary were the ones who encountered the greatest problems with financing (93.8%). Perhaps this is one of the most important aspects to improve so that all students have equal opportunities to attend these programs without their personal finances being handicapped.

5. Conclusion

The Erasmus+ BIP program has proven to be an academic and personal enriching experience for the students of the participating universities. The program structure, which combines online and face-to-face phases, has effectively facilitated physics learning and promoted the development of social and collaborative skills among students. Survey results indicate high satisfaction with the

program, although they also highlight areas for improvement, particularly in administrative management. The experience has underscored the importance of international cooperation.

Being part of the BIP program has enabled students to enhance their theoretical and practical knowledge of physics, develop interpersonal skills, and increase their motivation to continue their studies. Such initiatives are valuable to complement traditional teaching methods, providing a more comprehensive and multidimensional education. We believe these programs are very important and helpful, especially in subjects taught in the first years, where achieving student motivation is crucial to obtaining satisfactory academic results. Promoting mobilities of this type can engage students who will be great professionals tomorrow.

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

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