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Designing Engagement in a Cross-Level Blended Intensive Programme: An Empirical Study in Computer Science Higher Education

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Abstract: Blended Intensive Programmes (BIPs) bring together students at different academic levels for short, intensive international programmes, yet little is known about how to design engagement for such heterogeneous cohorts. This study examines engagement in cross-level learning, conceptualising it as an orchestrated outcome of four design dimensions: formal learning activities, preparatory and digital scaffolding, informal social interaction, and cross-level group composition. An Erasmus+ BIP on Large Language Model applications attended by bachelor's, master's and PhD students served as the case: 23 students and 3 instructors completed questionnaires with Likert-scale and open-ended items, analysed with descriptive statistics, non-parametric tests and thematic analysis. Activity types differed most clearly in social interaction ($\chi^2(4) = 34.09$, $p < .001$, Kendall's $W = .37$) and participation, and not in interest. Group work and informal social activities engaged students irrespective of academic level and prior familiarity, and most students valued working in mixed-level groups. Prior familiarity, more than academic level, was associated with engagement in instructor-led formats and with perceived self-efficacy. For future BIPs, these results point to collaborative and informal activities as common ground, to shared digital tools as effective support, and to preparatory scaffolding and early group formation as ways of levelling starting points.

Keywords: student engagement; Blended Intensive Programmes; cross-level learning; higher education; Erasmus+

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1. Introduction

Blended Intensive Programmes (BIPs) are becoming an increasingly relevant format in European higher education, combining short-term physical mobility, online learning activities and international collaboration. Recent empirical studies have begun to examine BIPs as pedagogical and organisational formats, focusing on blended mobility, programme effectiveness, student satisfaction, internationalisation, intercultural teamwork and multi-stakeholder collaboration (O'Dowd & Werner, 2024; de Prada et al., 2025; Laine et al., 2025). These contributions show the educational potential of BIPs, but they also suggest that research on this format is still at an early stage. In particular, less attention has been paid to how engagement is intentionally designed within BIPs and how different elements of the learning

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

environment contribute to different forms of student participation. This mirrors a broader pattern in research on engagement and educational technology in higher education: a systematic evidence map of 243 studies found that few defined student engagement and fewer than half drew on a theoretical framework (Bond et al., 2020).

This paper addresses this gap by examining student engagement in a cross-level, blended and international BIP in Computer Science. Rather than treating the BIP as a single instructional intervention to be evaluated mainly in terms of overall satisfaction, the study analyses it as an engagement ecosystem, operationalised through four design dimensions: formal learning activities, preparatory and digital scaffolding, informal social interaction, and cross-level group composition. This view is consistent with accounts of engagement as arising at the interface between student and institutional factors, mediated by psychosocial mechanisms such as self-efficacy, emotions, belonging and well-being (Kahu & Nelson, 2018). Building on questionnaire data collected at the end of the programme's third edition, the paper provides empirical evidence on how these four dimensions relate to students' and instructors' perceptions of engagement.

The contribution is threefold. First, the study conceptualises engagement in BIPs as an orchestrated phenomenon rather than as an individual disposition or a generic outcome of blended mobility. Second, it introduces an activity- and environment-based analytical framework that can be transferred to other short-term international learning programmes. Third, it foregrounds cross-level learning as a distinctive design choice, examining how the coexistence of bachelor, master and PhD students can be understood not merely as heterogeneity to manage, but as a resource for differentiated engagement, mentoring, academic inspiration and research-oriented interaction.

In doing so, the study offers a bridge between research on student engagement, blended learning, internationalisation and Computer Science education. It is particularly relevant for advanced technological domains such as trustworthy AI and secure LLM deployment, where effective learning requires the integration of conceptual understanding, hands-on practice, ethical awareness, collaborative problem solving and exposure to research communities.

1.1. The BIP Context

The empirical setting is the third edition of the Erasmus+ BIP *LLM Applications: From Core Concepts to Secure Deployment* (https://aibd.unica.it/bip_2026/index.php), organised at the University of Cagliari and devoted to secure, reliable and responsible applications based on Large Language Models. It comprised three online days (22–24 June 2026) on foundational topics in software development, machine learning and deep learning, and five on-site days (13–17 July 2026), and involved 27 students from six institutions in six European countries and 8 instructors.

The programme design has evolved across three editions, informed by participant feedback and by design tensions typical of intensive international programmes: balancing theory and practice, supporting participants with different backgrounds, and creating opportunities for informal interaction. The study examines four design dimensions that characterise the BIP.

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

First, formal learning activities comprise lectures, which provide conceptual grounding, tutorials, which support practical application, keynotes, which expose students to research perspectives, and group activities, in which participants design and present project-based solutions.

Second, preparatory and digital scaffolding includes an online phase a few weeks before the on-site week, a shared online repository and a Slack workspace.

Third, informal social spaces include coffee breaks, shared lunches, a social dinner and free time, considered as opportunities for community building and intercultural interaction.

Fourth, the cohort is intentionally cross-level: bachelor, master and PhD students were assigned by the organisers to mixed groups balanced by gender, institution and academic level, announced on the second on-site day. The six keynote seminars were concentrated in the last two days of the week.

This heterogeneity is treated as a pedagogical resource and not only as a difficulty: bachelor students may gain early exposure to advanced topics, master students may consolidate emerging expertise, and PhD students may engage in networking and informal mentoring. The study therefore investigates how different forms of engagement are enabled for participants at different academic stages.

1.2. Theoretical Framework and Research Questions

The study is grounded in a multidimensional understanding of student engagement, which the literature commonly describes in terms of behavioural, emotional and cognitive dimensions (Fredricks et al., 2004; Kahu, 2013). A social dimension is added here, following frameworks that list social and collaborative engagement as distinct elements alongside cognitive, behavioural and emotional engagement (Redmond et al., 2018). Measuring engagement separately for each activity type follows the recommendation that, in blended environments, engagement be measured at the level of the activity rather than of the institution (Halverson & Graham, 2019).

The main research question is: How can engagement be designed and experienced in a cross-level, blended, international Computer Science BIP through the orchestration of formal learning activities, preparatory digital support, informal social interaction and mixed-group project work? Four sub-questions guide the empirical analysis.

1. How do lectures, tutorials, keynotes and group activities contribute to different dimensions of perceived engagement?
2. How do the online preparatory phase and digital support spaces contribute to perceived readiness, self-efficacy and participation?
3. How do bachelor, master and PhD students experience engagement, and how does the cross-level design support peer learning and mentoring?
4. How do informal social spaces contribute to belonging and intercultural interaction?

2. Materials and Methods

A questionnaire was administered online on the final day of the on-site week to the 27 students and to the 5 instructors from partner institutions; the 3 instructors from the host institution did not take part. Twenty-three students (14 bachelor's, 5

master's, 4 PhD; response rate 85%) and three instructors (60%) responded. Informed consent was obtained, and participation was voluntary and anonymous.

The student version included a five-item battery (participation, critical thinking, interest, social interaction, overall engagement) rated separately for five activity types (lectures, tutorials, keynote seminars, group activities, social activities), a forced ranking of the five activities, single items on the design dimensions, self-rated prior familiarity with LLM and AI topics, and open-ended questions. Agreement that one was able to contribute meaningfully to the group regardless of academic level is used as a single-item indicator of perceived self-efficacy in group work. The instructor version contained parallel items for the four formal learning activities. Agreement items used a five-point scale (1 = strongly disagree, 5 = strongly agree).

Given the small sample, the analysis is exploratory. Differences across activity types were tested with Friedman tests, with Kendall's W as effect size and Holm-corrected Wilcoxon signed-rank tests as post-hoc comparisons; the internal consistency of the battery was acceptable to high (Cronbach's α = .78–.93). Spearman correlations, unadjusted for multiple testing, were used to explore associations with prior familiarity and academic level. Open-ended responses were analysed thematically, comparing student and instructor perspectives.

3. Results

Results are organised around the four sub-questions. Instructor results (N = 3) are interpreted descriptively.

3.1. Engagement Across Activity Types

Table 1 and Figure 1 show how students rated the five activity types on the five engagement dimensions. Group work and social activities received higher ratings than lectures, tutorials and keynote seminars (the instructor-led formats). The tests in Table 2 show clear pairwise differences on two dimensions, participation and social interaction: on both, lectures, tutorials and keynotes were each rated lower than group work and social activities, while the three did not differ from one another. It may seem obvious that social activities score high on social interaction, but the same result holds for group work and for participation. On critical thinking and overall engagement the differences were small, and on interest there was none. In short, what distinguishes the activities is how much students take part and interact, not how interesting they find them.

Table 1. Mean student-reported engagement ratings by activity type and engagement dimension (1–5 Likert scale, N = 23).

Activity	Particip.	Crit. Think.	Interest	Soc. Inter.	Overall Eng.	Mean
Lectures	3.65	3.74	4.09	3.39	4.04	3.78
Tutorials	3.78	3.78	4.13	3.39	3.83	3.78
Keynote seminars	3.65	3.87	4.09	3.35	3.87	3.77
Group activities	4.48	4.26	4.17	4.43	4.22	4.31
Social activities	4.52	3.83	4.39	4.35	4.30	4.28

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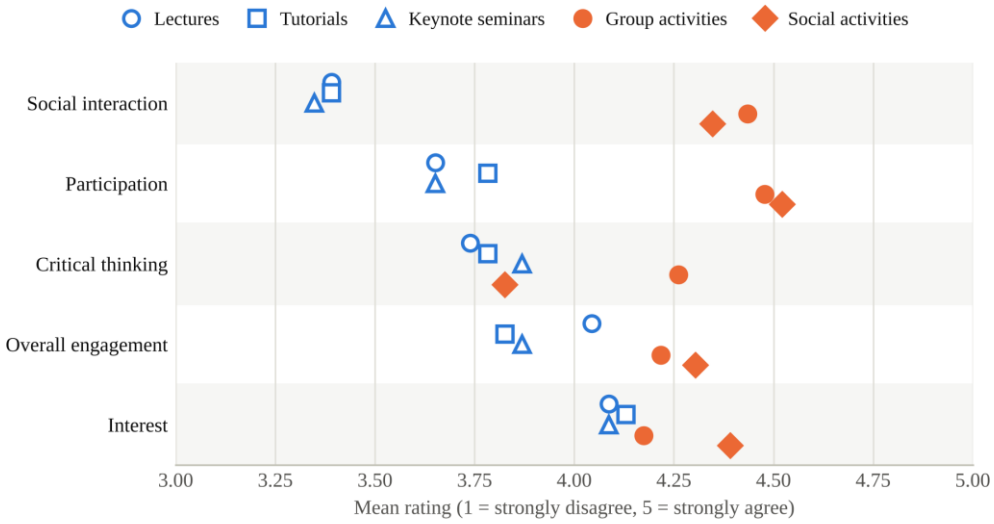
Note. Scale 1 = strongly disagree, 5 = strongly agree. Particip. = Participation; Crit. Think. = Critical thinking; Soc. Inter. = Social interaction; Overall Eng. = Overall engagement; Mean = mean of the five dimensions.

Table 2. Friedman tests of differences across the five activity types, by engagement dimension (N = 23).

Dimension	$\chi^2(4)$	p	W	Pairwise differences after Holm correction
Participation	31.26	< .001	.34	Each instructor-led format rated lower than group and social activities
Critical thinking	10.11	.039	.11	None
Interest	7.14	.129	.08	Not tested
Social interaction	34.09	< .001	.37	Each instructor-led format rated lower than group and social activities
Overall engagement	11.02	.026	.12	None
Composite (mean of five items)	30.25	< .001	.33	Each instructor-led format lower than group activities; lectures and tutorials lower than social activities

Note. W = Kendall's coefficient of concordance. Pairwise comparisons are Wilcoxon signed-rank tests; instructor-led formats are lectures, tutorials and keynote seminars.

Figure 1. Mean ratings of the five activity types on each engagement dimension. Hollow markers indicate instructor-led formats; the axis shows the range 3 to 5.



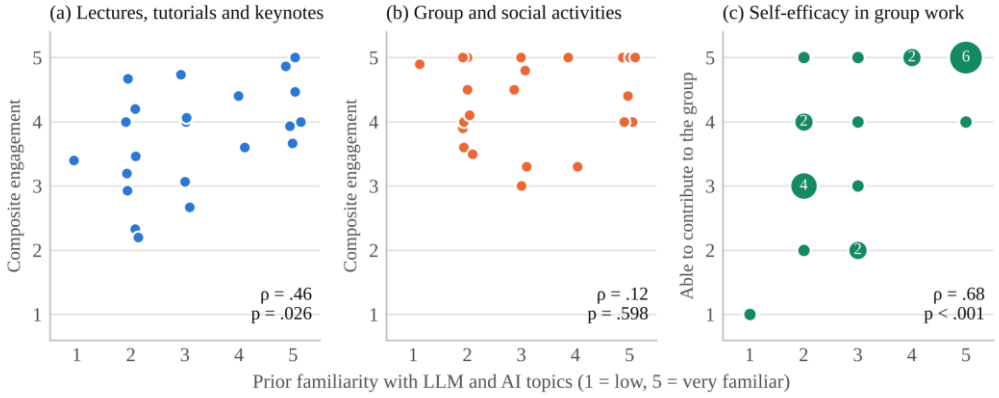
The forced-ranking item was consistent with this pattern: social activities were ranked most engaging by 13 of the 23 students and keynote seminars least engaging by 9. On the ratings, however, keynotes were indistinguishable from the other instructor-led formats; their concentration in the last two days of an intensive week may also contribute. Open-ended responses on which activity contributed most to learning were split between tutorials and group work, valued for their applied character ("it is really important to know how to apply the theory we learned"), and keynotes or lectures, valued for conceptual depth. Instructor-led formats therefore

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

appear to retain a cognitive role without generating comparable participation or social engagement. Instructors also rated group activities highest, and gave different answers on which format is hardest to keep students engaged in.

Prior familiarity with the topics qualified this picture (Figure 2). It was positively associated with engagement in the instructor-led formats but not in group and social activities, where a ceiling effect may also play a part.

Figure 2. Prior familiarity with LLM and AI topics in relation to composite engagement (a, b) and perceived self-efficacy in group work (c). ϱ = Spearman's rank correlation; N = 23.



3.2. Preparatory Phase, Digital Scaffolding and Self-Efficacy

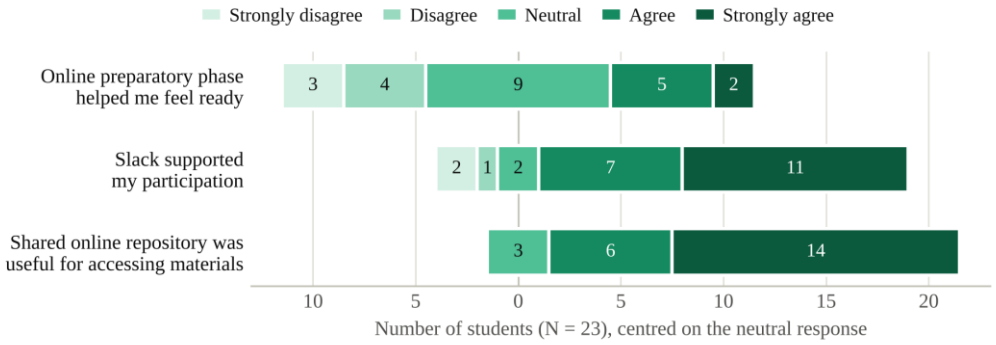
Table 3 summarises the single-item measures. Students rated the two digital tools highly, whereas their agreement that the online preparatory phase "helped me feel ready for the in-person activities" was neutral on average, with responses spread across the scale (Figure 3). The contrast suggests that readiness for cross-level work depends less on the tools than on the content and format of what happens before students meet. Open-ended responses converge on a few concrete suggestions: forming project groups during the online phase, so that participants can begin interacting before the on-site week ("it was hard to socialize the first 2 days"); posting materials in advance for students with less prior background; and adding short interactive elements to the online sessions. Instructors rated the phase highly, and one independently suggested that groups "should be created earlier (perhaps in the online sessions)". The two perspectives apply different criteria: instructors judge whether the phase delivered its content as intended, students whether it made them feel ready to work with others.

Table 3. Single-item measures by design dimension: student means and standard deviations (N = 23) and instructor means (N = 3).

Item	Students, M (SD)	Instructors, M
Preparatory phase and digital tools		
Online phase helped students feel ready for the on-site activities	2.96 (1.15)	4.7
Shared online repository was useful	4.48 (0.73)	4.7
Slack workspace supported participation	4.04 (1.26)	5.0
Cross-level group composition		
Mixed-level groups were valuable for learning	4.30 (1.02)	4.7
Able to contribute meaningfully regardless of academic level	3.83 (1.27)	n/a
Informal social interaction and belonging		
Sense of belonging within the BIP community	4.30 (0.70)	n/a
Informal social spaces helped build relationships	4.48 (0.67)	5.0
Comfortable engaging with participants from other cultures	4.52 (0.67)	n/a
Overall experience		
Overall satisfaction with the BIP	4.39 (0.58)	5.0
Learned something useful for academic development	4.39 (0.78)	n/a
Learned something useful for professional development	4.57 (0.59)	n/a

Note. Scale 1 = strongly disagree, 5 = strongly agree, except overall satisfaction (5 = extremely satisfied). Instructor items were worded from the instructor's perspective (for example, whether the online phase adequately prepared students); n/a = item not included in the instructor version.

Figure 3. Distribution of student responses on the preparatory phase and on the two digital tools, centred on the neutral response. Numbers inside the bars are counts of students.



The preparatory phase also showed no association with perceived self-efficacy in group work. Students' agreement that they were able to contribute meaningfully to their group was unrelated to perceived readiness and to their ratings of the two digital tools. It was instead strongly associated with prior familiarity with the topics ($\varrho = .68$, $p < .001$; Figure 2c), also within the bachelor's subgroup alone. This helps to locate the design lever: the digital tools supported participation, whereas levelling students' starting points appears to require preparatory content matched to prior familiarity and earlier contact among students.

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

3.3. Cross-Level Cohort Dynamics

Engagement profiles were similar across academic levels. Composite engagement in group and social activities was high among bachelor's (4.29), master's (4.50) and PhD students (4.05), exceeded engagement in instructor-led formats at every level and was higher for 18 of the 23 students individually. Eighteen students agreed that working in a mixed-level group was valuable for their learning. Self-efficacy was more closely associated with prior familiarity (ρ = .68) than with academic level (ρ = .30, p = .169): the heterogeneity that mattered for cross-level work was prior familiarity more than formal seniority.

Open-ended accounts point to three mechanisms: knowledge transfer from more to less experienced members, the most frequent; calibration of one's own knowledge against that of others; and reciprocity, which one participant described as "reciprocal learning". They also show that roles follow perceived seniority: one senior participant was expected to coordinate the group's work on the basis of age and years of study alone. Instructors confirmed the mentoring dynamic and noted that "differences in experience can create a burden for more experienced users". Ratings from the four PhD respondents were the most dispersed, so the benefits for the most senior participants deserve explicit attention.

3.4. Informal Social Interaction and Belonging

Most students reported a sense of belonging within the BIP community, that informal social spaces helped them build relationships across countries and institutions, and that they felt comfortable with participants from other cultural backgrounds (Table 3). Networking and intercultural exchange were most often named as the most valuable aspect of the programme.

Instructors' qualitative responses support this picture. All three described informal social spaces as important for engagement, and one reported cross-cultural bonding outside any formal activity (students watching World Cup matches or going to the beach together), linking these moments to the sharing of knowledge and experience around the group projects.

4. Discussion

Across all four sub-questions, a consistent picture emerges: experiential and informal elements of the BIP (group project work and social activities) were rated higher than the instructor-led formats, particularly on social interaction and participation, while the instructor-led formats retain a cognitive role. This is consistent with a mixed-methods study of another BIP, in which students preferred face-to-face to virtual contact and rated the virtual component lowest (de Prada et al., 2025), and extends this literature by describing, at the level of individual design dimensions, where perceived engagement concentrates. The higher ratings for group work are also in line with meta-analytic evidence from undergraduate STEM education on active learning (Freeman et al., 2014) and small-group learning (Springer et al., 1999), although that evidence concerns performance. The prominence of informal social spaces is consistent with work identifying social engagement as one of the domains of students' sense of belonging (Ahn & Davis, 2020). Finally, perceived self-efficacy in group work, one of the mechanisms

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

through which engagement is thought to arise (Kahu & Nelson, 2018), was associated with prior familiarity and not with the preparatory phase.

These results support the paper's threefold contribution. First, engagement is orchestrated rather than uniform: it varies by activity type and by engagement dimension, so that a single satisfaction score would have obscured where engagement concentrates (participation and social interaction) and the fact that students can find an activity valuable for their learning without finding it the most engaging, as the evidence on tutorials and keynotes shows. That evidence echoes experimental findings that students' perceptions of their own learning are not a reliable guide to the effectiveness of an activity: in a controlled comparison in introductory physics, students in active classrooms learned more but rated their learning lower than students attending lectures by highly rated instructors (Deslauriers et al., 2019). Second, the activity- and environment-based framework used here, which distinguishes formal activities, digital scaffolding, informal interaction and cross-level composition, surfaced distinct and independently actionable findings for each dimension, and is in principle transferable to other short-term international programmes such as those described by Laine et al. (2025). Third, cross-level composition worked as a resource: most students valued it, engagement in collaborative activities was high at every academic level, and students' accounts describe knowledge transfer, calibration and reciprocity, consistent with evidence that in peer learning helpers benefit as much as those they help (Topping, 2005). The open design question concerns roles, since seniority tended to translate by default into coordination work, a cost also reported for mentors in formal peer mentoring programmes, whose main concerns were balancing mentoring with their other commitments and students becoming dependent on them (Colvin & Ashman, 2010).

Five design principles for cross-level blended programmes follow.

1. Collaborative and informal activities can be treated as the common ground of a heterogeneous cohort and deserve protected time rather than what is left over from instruction.
2. Preparatory scaffolding is best aimed at differences in prior familiarity, which academic level captures only loosely, and group formation can be brought forward into the online phase, a step proposed independently by students and by an instructor.
3. Shared digital tools were effective in supporting participation and can carry this earlier contact among students.
4. Roles within mixed groups benefit from being made explicit, so that the contribution of the most senior participants is recognised and their own benefits are designed for rather than assumed.
5. Pairing instructor-led formats with moments of interaction may extend their reach to students who are less familiar with the content.

These findings should be read with several limitations in mind. The cohort is small and self-selected, and the instructor sample and the PhD subgroup support only descriptive interpretation. The study covers a single edition of one programme and relies on self-reported data from a questionnaire developed for it. The correlational analyses are exploratory and no causal claims are intended: the aim is to understand how engagement is designed and perceived in a situated setting.

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

5. Conclusions

This study examined how engagement is designed and experienced in cross-level learning, using a blended, international Computer Science BIP as a case and combining a comparative quantitative battery with thematic analysis of open-ended responses. The results suggest that engagement in such programmes is shaped less by how interesting each activity is than by the participation and social interaction it affords. Collaborative project work and informal social activities engaged bachelor's, master's and PhD students alike and regardless of prior familiarity, and most students valued working in mixed-level groups. Instructor-led formats retained a cognitive role and engaged most strongly the students who were already familiar with the topics, and perceived self-efficacy in group work followed prior familiarity more than academic level. For the design of future BIPs, this points to collaborative and informal activities as the common ground of a heterogeneous cohort, and to preparatory scaffolding, early group formation and explicit roles as the levers through which a cross-level design can be made to work for every participant. Future work should extend this activity- and environment-based framework across further editions and institutions, with larger samples and a longitudinal design, to test whether these patterns hold.

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