UNIVERSITÀ DEGLI STUDI DI BERGAMO

BLISS

Erasmus +: BLISS

Blended Learning Implementation for reSilient, acceSsible and efficient higher education

Project 2021-1-SE01-KA220-HED-000023166

Project Result 2 – Deliverable 2.3.1
Requirement for new curricula definition

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them

2022-2025

Edited By: Roberto Sala, Fabiana Pirola, Giuditta Pezzotta, UNIBG

Reviewed by: Antonio Maffei, Fabio Marco Monetti, KTH

Table of Contents

Document heading

Project title:	**Blended Learning Implementation for reSilient, acceSsible and efficient higher education**
Project result:	**2**
Leading org.:	**University of Bergamo**
Output title:	**Requirement for new curricula definition**
Authors:	**University of Bergamo with input from the entire consortium**

Project Result 2 summary:

Project Result implementation

Analysis of the available literature in BL. This activity is aimed to contextualize the Covid-19 experience and suggest a novel view based on highlighting and structuring the use of successful patterns emerging from the study. The literature will be also complemented by a specific LTT about BL hosted by the Royal Institute of Technology. This activity will concur in producing the result 2 and contribute to the general literature in the domain

- **Needs analysis** Blended strategies are widely considered more efficient than fully online or in-person approaches, as they promote engagement, offer flexibility, and reduce costs for students and institutions. This hybrid approach is particularly beneficial for achieving complex learning goals, prompting many HEIs to transform their curricula. The BLISS initiative aims to support these efforts by leveraging data from the pandemic and identifying best practices. A successful blended learning strategy involves balancing face-to-face and online time while considering factors like feedback, digital literacy, and workload.
- **Target group** This activity directly targets teachers and program coordinators at HEIs in the consortium. However, its open results will benefit similar roles in other institutions as well. The reflection on best practices will also support future students studying the defined curricula. These curricula are based on the requirements identified through this activity.
- **Elements of innovation** This task will analyze existing literature in the context of the Covid-19 pandemic. The new perspective will highlight how HEIs can enhance the resiliency of their educational offerings. It will also explore ways to increase efficiency and engagement. Finally, it aims to improve accessibility.
- **Expected impact** This task will provide the theoretical foundation to define improved curricula based on rational use of blended learning.
- **Transferability potential** Both the research diary and the requirement specification will be transferred to the academic learning community through an open-access publication and shared through the planned dissemination activities (see related section)

UNIBG will lead the effort of reviewing the leading edge literature in the suggested domain. Each partner will contribute in relation to their specific technical expertise. Task 2.1 Literature analysis. Each partner will engage in a traditional literature analysis that, when possible, will be integrated with review of practices from universities available in different MOOC platforms or even industrial partners. In detail, each partner will identify and describe state of the art in one of the following blended learning approaches: 1. UNIBG. Face-to-face driver – where the teacher drives the instruction and augments with digital tools. 2. KTH. Rotation – students cycle through a schedule of independent online study and face-to-face classroom time. 3. POLITO. Flex – most of the curriculum is delivered via a digital platform and teachers are available for face-to-face consultation and support. 4. UNILJ. Labs – all of the curriculum is delivered via a digital platform but in a consistent physical location. Students usually take traditional classes in this model as well. 5. UNIMA. Self-blend – Students choose to augment their traditional learning with online course work. 6. UNIRI. Online driver – Students complete an entire course through an online platform with possible teacher check-ins. All curriculum and teaching is delivered via a digital platform and face-to-face meetings are scheduled or made available if necessary Deliverable (2.1.1): Single institution research diaries. Task 2.2. Synchronization and research diary. A bi-weekly online pulse meeting will be organized by UNIBG to update the consortium on the single efforts and iteratively compile the research diary resulting from the effort. Deliverable (2.2.1): Research diary Task 2.3. Formulation of the requirements for blended learning engineering curricula The research diary findings will be matched with existing engineering curricula in

order to highlight the potential for the definition of alternative blended learning strategies considering both technological and pedagogical aspects. In detail activities will be classified as follow: 1. Existing suitable blended approach. Recommendation: keep. 2. Traditional activity that can benefit from a blended approach. Recommendation: develop 3. Other activities. The activities in category 2 will be zanalyzed and the following related requirement for development highlighted: - Focal intended learning outcome - Eligible blended learning approaches - Teacher necessary activity - Student planned activity - Impact on the assessment task The result of this activity will be furtherly refined and used in the following planned Result 3. Deliverable (2.3.1): Requirement for new curricula definition Deliverable (2.3.2): Open access paper summarizing the finding of this activit

Division of work

Activity Leadership and Planning UNIBG led this activity and organized the related work as planned.

Task 2.1 Literature analysis. Starting from the necessity to have a complete overview on the experiences described in the literature for the implementation and use fo Blended Learning approaches in the engineering courses, a literature analysis was carried out. After defining the research query, papers were classified according to the learning approach presented (i.e., Face-to-Face, Rotation, Flex, Labs, Self-Blend, Online), each partner institution was assigned to a single learning approach with the scope of analyzing the related papers (Table 1). During the analysis, each institution had to fill out a research diary in Excel format with required information to collect.

Table 1 - Learning approach and insitutions

Learning Approach	Short-Description	Institution
Face-to-face	The teacher drives the instruction and augments with digital tool	UNIBG
Rotation	Students cycle through a schedule of independent online study and face-to-face classroom time	KTH
Flex	Most of the curriculum is delivered via a digital platform and teachers are available for face-to-face consultation and support	FLEX
Labs	All of the curriculum is delivered via a digital platform but in a consistent physical location. Students usually take physical classes in this model as well	UNILJ
Self-Blend	Students choose to augment their physical learning with online course work	UNIMA
Online driver	Students complete an entire course through an online platform with possible teacher check-ins. All curriculum and teaching is delivered via a digital platform and face-to-face meetings are scheduled or made available if necessary	UNIRI

Task 2.2 Synchronization and research diary. Starting from the results of the previous task, UNIBG collected the single institutions' research diaries and scheduled a series of meeting to discuss the resolution of doubts emerged during the classification. As an output, a consortium research diary was obtained. This research diary contained the classification of all the papers extracted from the literature analysis and covered all the learning approaches. The synchronization of the research diaries was made with the contributions of all partners through a series of online meetings.

Task 2.3 Requirement for a new curricula definition. Following the creation of the consortium research diary, the file was analyzed to extract trends and capture the main insights that was possible to gain from the literature. Starting from this, a set of requirements for the definition of new curricula was created. Additionally, an open access paper, with the main insights and lessons learned, as well as the list of requirements, was published.

Project Result 2 in the context of the Project

PR1
- Conducted a comprehensive analysis of the diverse responses to the Covid-19 pandemic across different Higher Education Institutions (HEIs) within the consortium.
- Compiled and benchmarked the reactive measures implemented by various institutions to tackle the pandemic's impact on education

PR2
- Analyzed existing literature and Covid-19 experiences to identify successful blended learning strategies.
- Developed a research diary to highlight trends and define requirements for improving curricula through blended learning.

PR3
- Selected and developed at least three educational units based on identified requirements for blended learning.
- Created detailed syllabi for the selected educational units, ensuring alignment with pedagogical approaches.

PR4
- Implemented the new educational units and assessed their effectiveness in improving learning outcomes.
- Evaluated and documented the organizational impact of blended learning courses on the education system.

PR5
- Facilitated the exchange and implementation of developed educational units across consortium partners.
- Conducted a cross-evaluation of the educational units to propose environment-specific modifications for better applicability.

Results of the activities

The Project Result 2 goal was to define a set of requirements for the creation of new curricula based on Blended Learning in the engineering field. The definition of a standard classification approach for the single institutions' diaries favoured their integration into a complete consortium research diary and, in turn, the development of the analyses.

Query definition and paper classification

The query run in Scopus was the following: "TITLE-ABS-KEY (("blend* learn*") AND "engineer*") AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "ENGI"))". It was run at the beginning of the project and then at the beginning of 2023 to check any important deviations. The query initially returned 206 papers. Reading the title and abstract allowed to reduce the number of papers to 158. Finally, the reading of the full text allowed to reach the final pool of 103 papers to be analyzed.

The papers were initially clustered according to the learning approach discussed in the title and abstract. In case the paper discussed multiple approaches, the paper was assigned to all the involved partners.

A brief description of the learning approaches is provided in **Error! Reference source not found.**.

In addition to the standard information related to each paper (e.g., year of publication, source) the following information was extracted from each paper:

- Relevance to the research (High/Medium/Low)
- What research gap is the paper trying to address
- Country of application
- Degree level (if any) (e.g., Bachelor, Master, PhD)
- Degree year (if any)
- Degree (if any)
- Course (if any)
- Technology typology
- Technology (specific)
- Learning_Approach
- Blooms_Level_Face_to_Face
- Blooms_Level_Online
- Results
- Related to covid (Yes/No)
- Phase of the covid (Before/During /After)

Bloom's Taxonomy

In this conceptualization, 6 different, increasingly sophisticated, levels of understanding are identified. Each level is then populated with a set of verbs that represents the associated learning actions. In detail:

Table 2 - Bloom's Taxonomy

Level	Name	Verbs	Description
1	Remembering (Recall and Recognition)	Define, duplicate, list, memorize, repeat, state	At this level, learners recall and recognize information without necessarily understanding its meaning. They can define terms, reproduce facts, or list items from memory.
2	Understanding (Comprehension)	Classify, describe, discuss, explain, identify, locate, recognize, report, select, translate	Learners grasp the meaning of information and can explain it in their own words. They are able to classify, describe, or identify concepts and ideas.
3	Applying (Application)	Execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch	At this level, learners use their acquired knowledge to solve problems or apply concepts in real-world situations. They can demonstrate skills and implement solutions.
4	Analyzing (Analysis)	Differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test	Learners break down information into its components, identify patterns, and make connections. They can analyze and evaluate relationships between different elements
5	Evaluating (Evaluation)	Appraise, argue, defend, judge, select, support, value, critique, weigh	At this level, learners make judgments about the value, validity, or quality of information. They can argue a point of view,

			support their opinions, and critically assess ideas.
6	Creating (Synthesis)	Design, assemble, construct, conjecture, develop, formulate, author, investigate	The highest level of Bloom's Taxonomy, learners generate new ideas, concepts, or products. They can design solutions, create hypotheses, and contribute to new developments.

Analyses

In the following, a brief description of the main results achieved from the analysis of the research diary is provided. For detailed discussion, the authors suggest to read the Open Access paper (Deliverable D2.3.2).

Concerning the publication trend (Figure 1), an increasing interest in the topic can be noticed. A peak can be noticed in 2020 followed by a decrease in 2021. Due to the moment of the research, publications in 2022 cannot be considered as completed, so the number of published papers on the topic might have increased. Also, the spreading of the COVID-19 pandemic might have affected the way teachers used to deliver courses, and time to evaluate changes might also have affected their publication process.

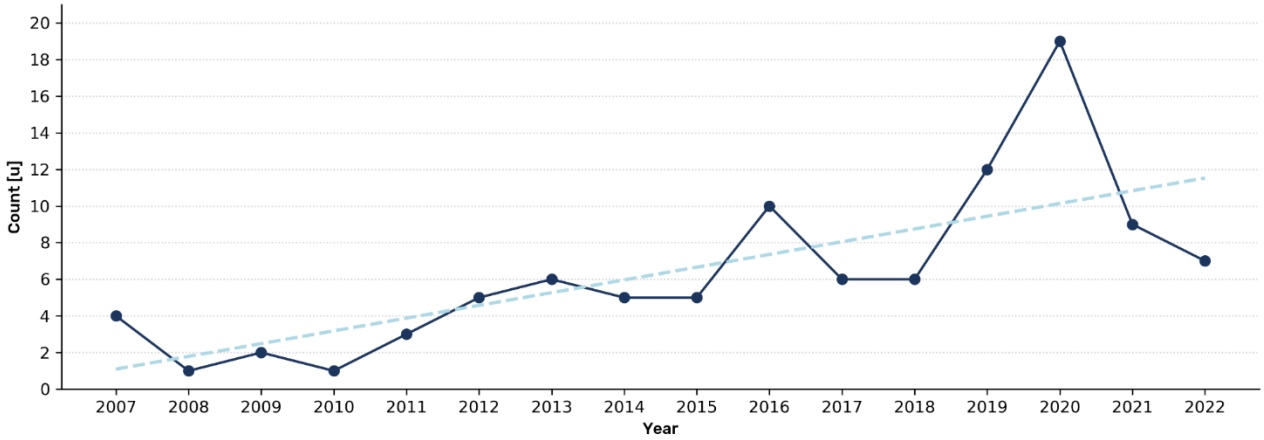

Figure 1 - Publications' trend

Considering the learning approach count (Figure 2), it can be noticed a strong prevalence of Rotation-based courses. This trend is also increasing according to Figure 3 not just for the Rotation but also for the Face-to-Face and Online approaches. In general, all the approaches, except for the Self-blend, seem to have increased their interest over time.

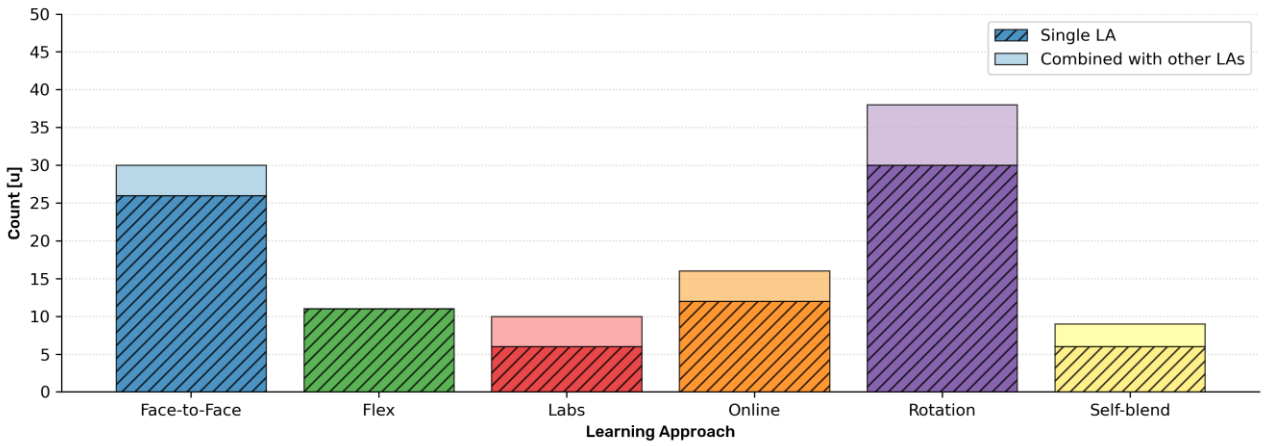

Figure 2 - Learning approaches: count

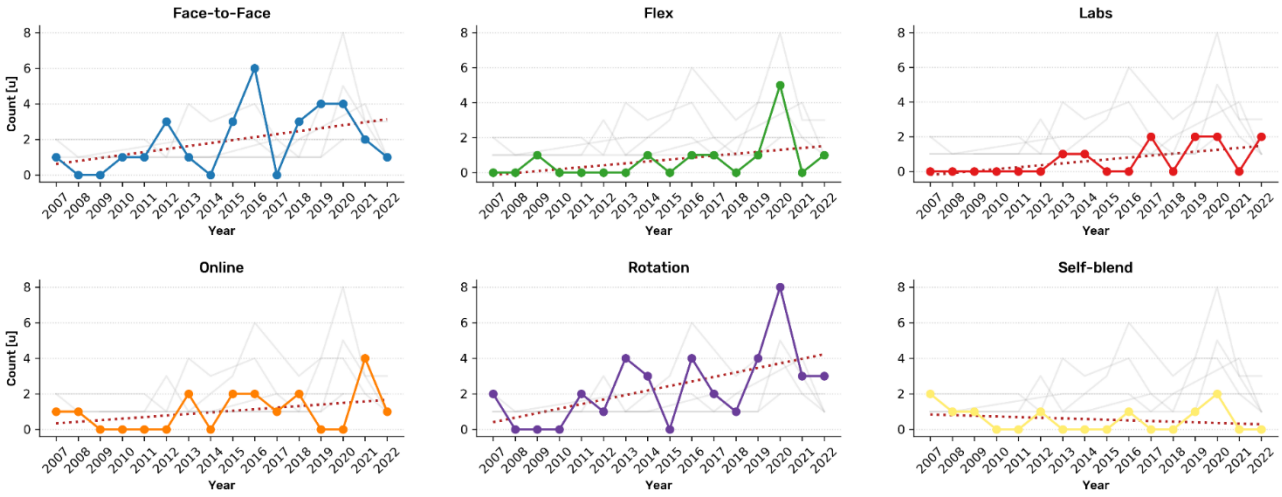

Figure 3 - Learning approaches: trend

The sample of papers showed interest all around the world for the topic (Figure 4).

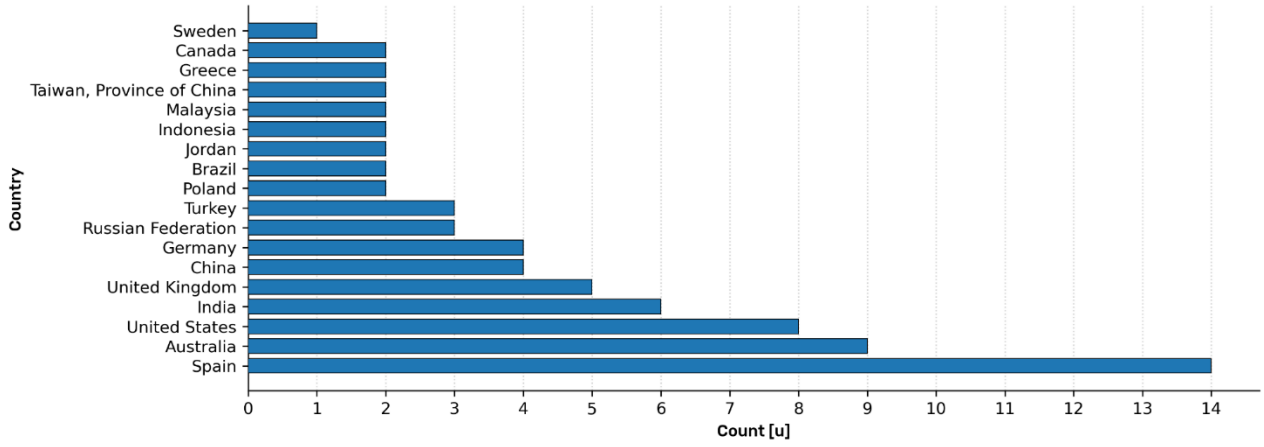

Figure 4 - Countries: count

Also, a variety of journals have been chosen for publishing the papers. Of course, the majority of journals dealt with education (Figure 5).

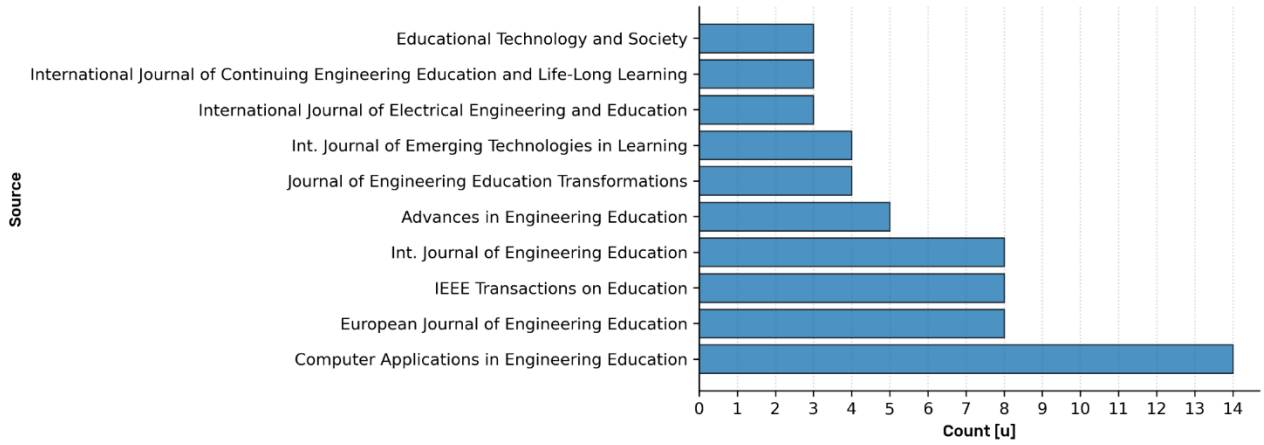

Figure 5 - Source: count

Analysing the sample, 337 unique keywords were found and as expected, “Blended learning” was the most common (Figure 6). Interestingly, few keywords on specific learning approaches were found.

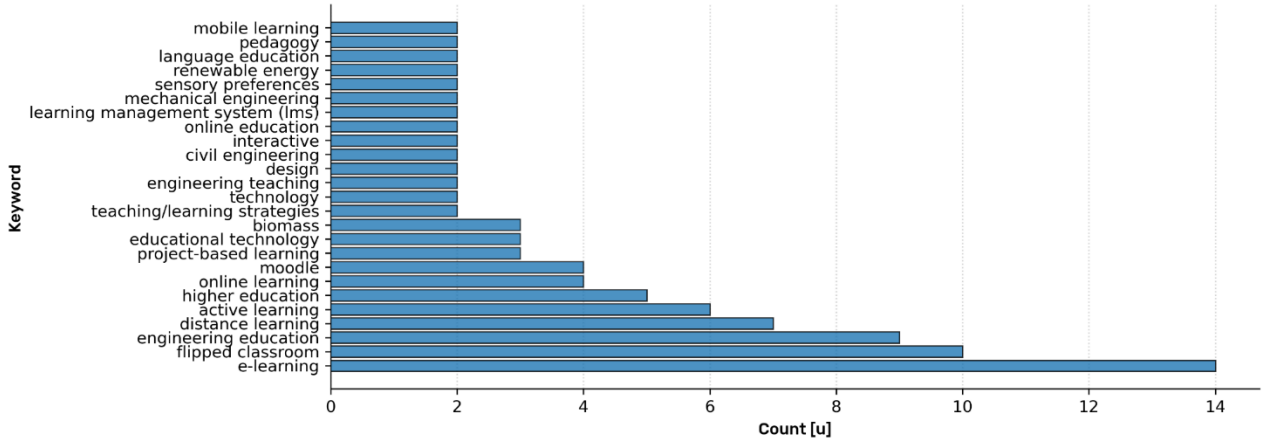

Figure 6 - Keywords: count

According to the results (Figure 7 and Figure 8) the majority of papers focused on evaluating the effects of adoption of blended learning. In addition, they focused on how to develop material for blended learning activities. Due to the increasing interest in BL, also the material development become an important topic over time. Also, to understand how to create proper BL courses, methods of evaluation of the BL effects were frequently addressed.

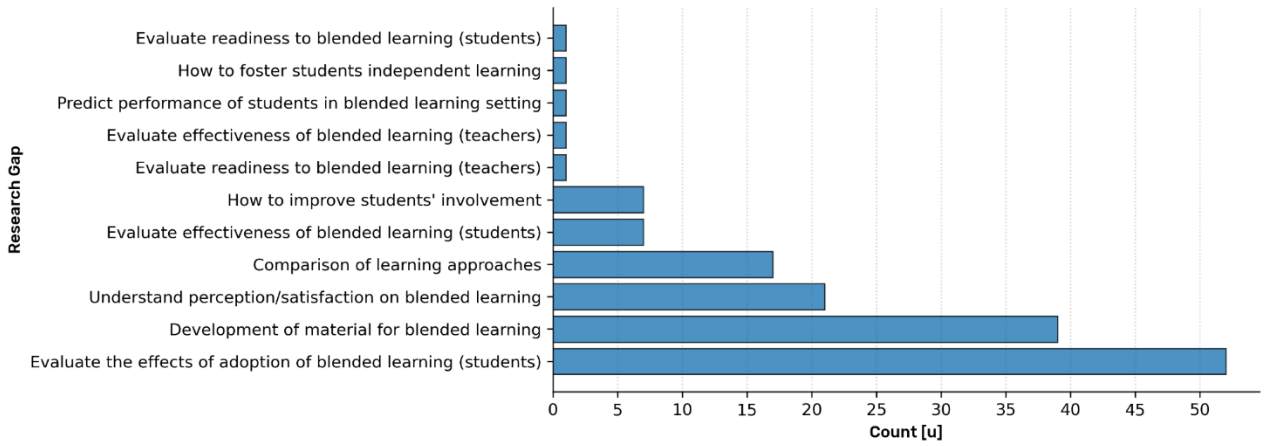

Figure 7 - Research gap: count

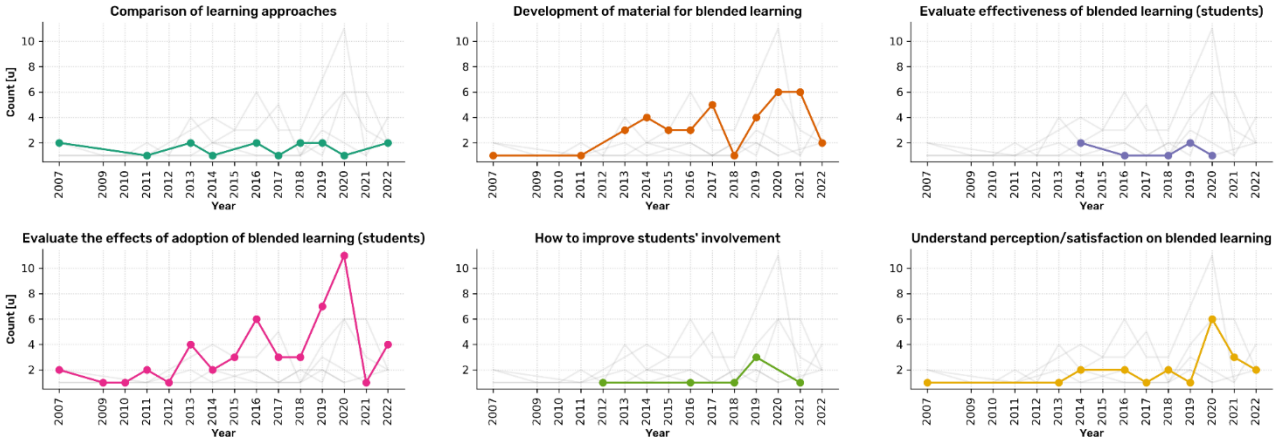

Figure 8 - Research gap: trend

Concerning, the target of the courses, the majority of applications focus on Bachelor courses (Figure 9).

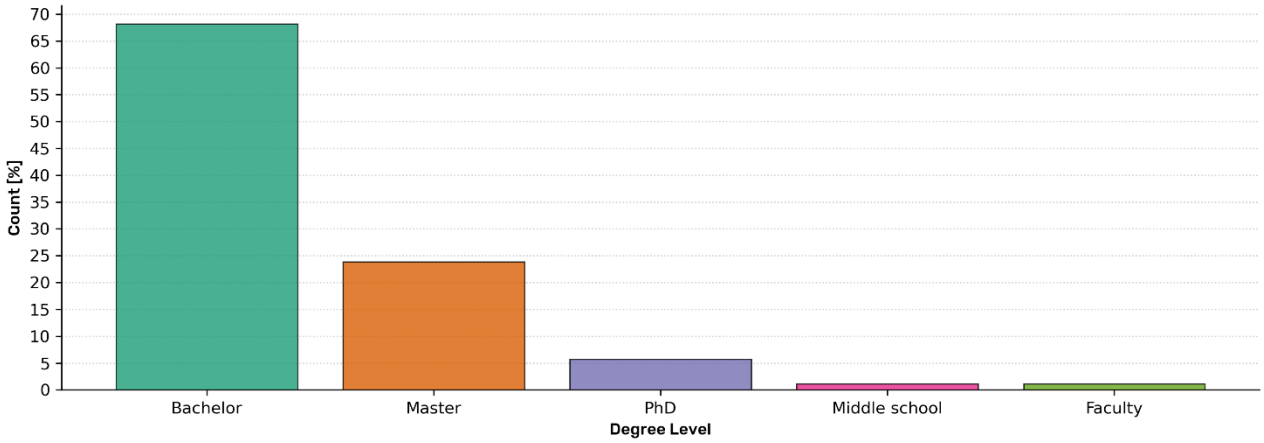

Figure 9 - Degree level: count

The Bloom's taxonomy levels were extracted for each described application. In particular, the authors tried to understand what level of the Bloom's taxonomy was usually adopted in the in place or remote setting (Figure 10). Concerning the in-place scenario, the majority of papers dealt with applications at lower levels of the Bloom's Taxonomy. The remote scenario is not that different, even though there is a prevalence of Understand compared to Apply. In general, lower levels are preferred to the higher ones.

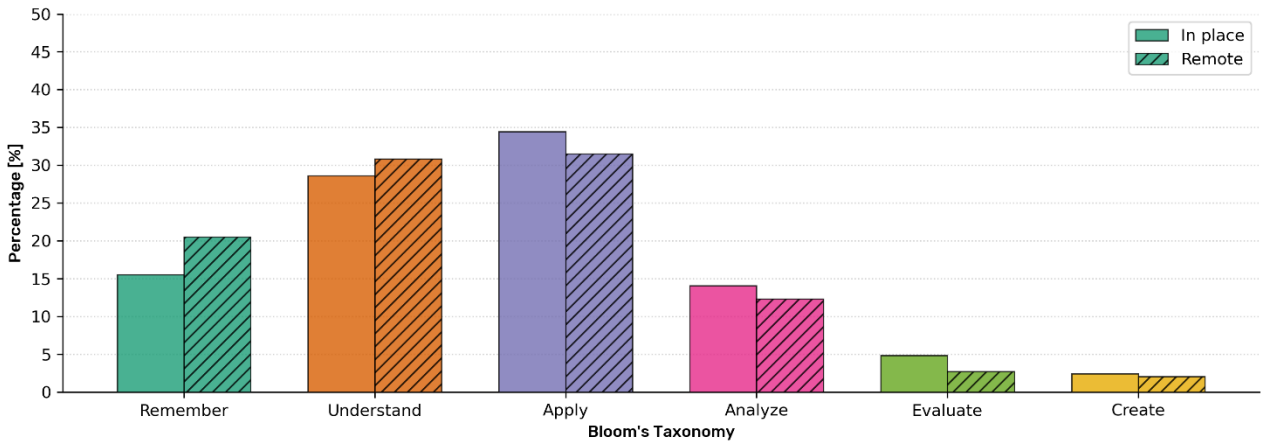

Figure 10 - Bloom's (Face-to-Face vs Online) taxonomy: count

According to Figure 11, there is not much difference in terms of trends. For the in place setting recent years showed some applications related to Evaluate and Create levels. Instead, for the remote setting some interest towards the Analyze and Evaluate levels was shown. Interestingly, for the remote setting no application in create was discussed.

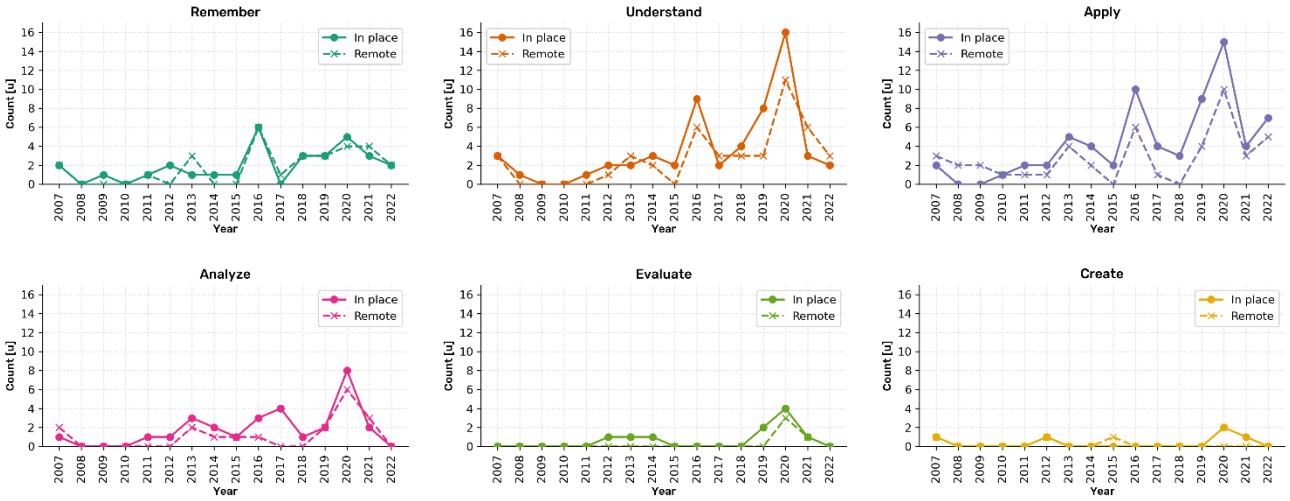

Figure 11 - Bloom's (Face-to-Face vs Online) taxonomy: trend

As far as results are concerned (Figure 12 and Figure 13), the majority of papers investigated the effectiveness of BL and collected suggestions from students o improve the way courses and lectures were delivered. In terms of trend, papers have shown a stable interest towards students' performance and an increasing interest towards effectiveness of blended learning and students' suggestions.

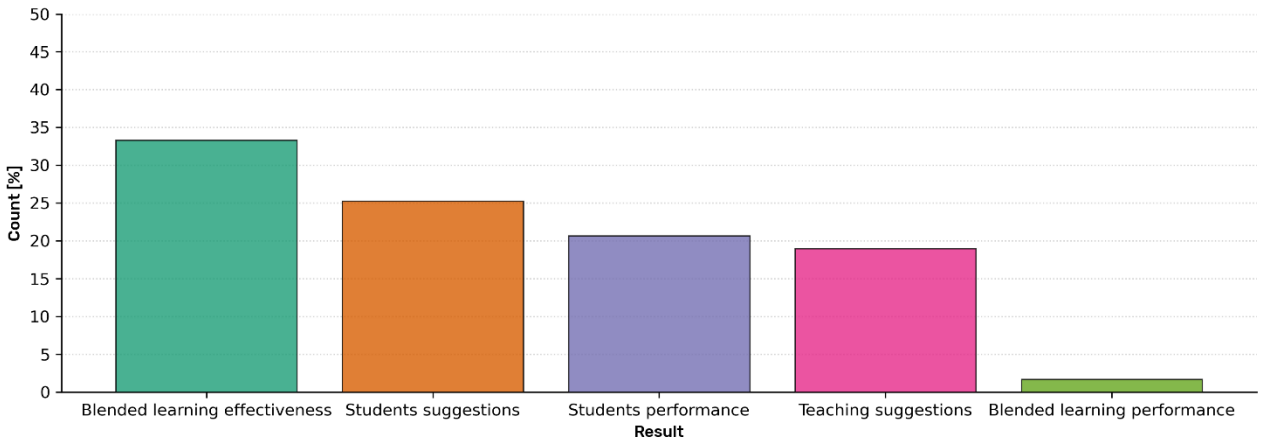

Figure 12 - Result: count

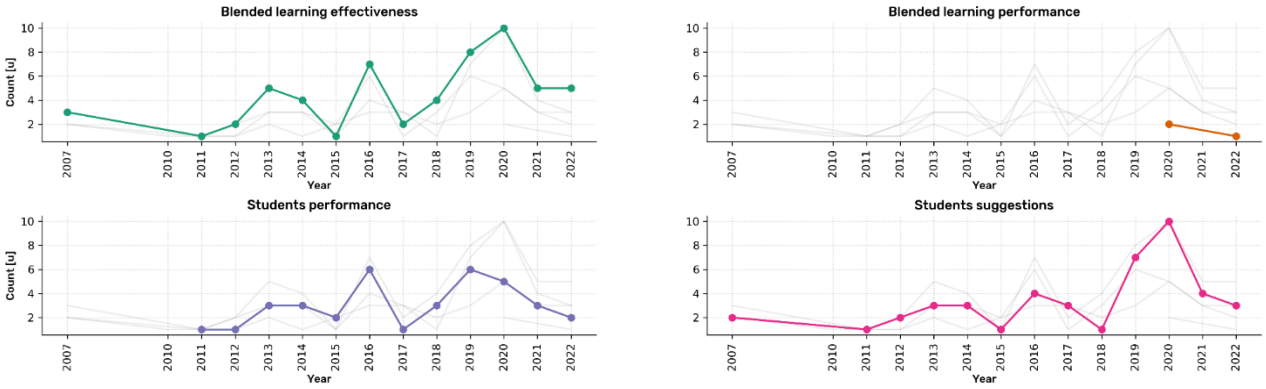

Figure 13 - Result: trend

Only a few papers were clearly related to Covid and focused on lower levels of the Bloom's taxonomy (Figure 14).

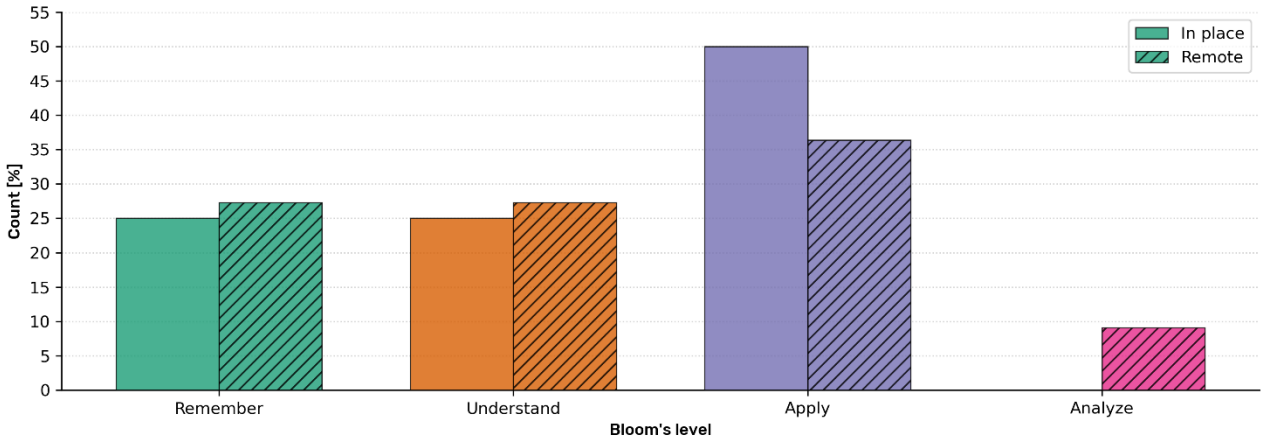

Figure 14 - Covid - Bloom's (Face-to-Face vs Online) taxonomy: count

The consortium decided then to compare the learning approach with the level of the Bloom's taxonomy for the in place and remote settings. In particular, Figure 15 and Figure 16 shows the analysis for the in place settings normalizing the distribution of papers by Bloom's level (Figure 15) and by learning approach (Figure 16). It is possible to notice that, according to the normalization by Bloom's level:

- Face-to-Face and Rotation the two most used. F2F for Remember sample, Rotation for the others.

- Self-blend significantly increases its contribution in the create sample

Instead, when normalizing by Learning Approach:

- Understand and apply are the two levels most frequently used by the majority of learning approaches. Only Fact-to-Face and Self-blend focus more on the Understand level.
- Only Fat-to-Face, Rotate and Self-blend achieve the create level.

Blooms_Level_Face_to_Face Learning_Approach	Remember	Understand	Apply	Analyze	Evaluate	Create
Face-to-Face	45.95%	30.43%	21.43%	0.00%	21.43%	20.00%
Flex	5.41%	5.80%	8.33%	15.79%	7.14%	0.00%
Labs	2.70%	10.14%	13.10%	21.05%	0.00%	0.00%
Online	5.41%	7.25%	5.95%	5.26%	7.14%	0.00%
Rotation	32.43%	36.23%	44.05%	52.63%	57.14%	60.00%
Self-blend	8.11%	10.14%	7.14%	5.26%	7.14%	20.00%

Figure 15 - Bloom's (Face-to-Face) level vs learning approach (normalization by column)

Blooms_Level_Face_to_Face Learning_Approach	Remember	Understand	Apply	Analyze	Evaluate	Create
Face-to-Face	28.33%	35.00%	30.00%	0.00%	5.00%	1.67%
Flex	11.76%	23.53%	41.18%	17.65%	5.88%	0.00%
Labs	4.35%	30.43%	47.83%	17.39%	0.00%	0.00%
Online	14.29%	35.71%	35.71%	7.14%	7.14%	0.00%
Rotation	12.63%	26.32%	38.95%	10.53%	8.42%	3.16%
Self-blend	15.79%	36.84%	31.58%	5.26%	5.26%	5.26%

Figure 16 - Bloom's (Face-to-Face) level vs learning approach (normalization by row)

Instead, Figure 17 and Figure 18 shows the analysis for the remote settings normalizing the distribution of papers by Bloom's level (Figure 17) and by learning approach (Figure 18). It is possible to notice that, according to the normalization by Bloom's level:

- Rotation is the most used.
- Self-blend is the most used in the Create sample

Instead, when normalizing by Learning Approach:

- Strong focus on lower levels, especially Understand and Apply, for all the learning approaches. Face-to-Face do something more for the Evaluate and Self-Blend for the Create

Blooms_Level_Online Learning_Approach	Remember	Understand	Apply	Analyze	Evaluate	Create
Face-to-Face	6.25%	6.52%	8.00%	0.00%	28.57%	0.00%
Flex	3.12%	17.39%	10.00%	15.79%	14.29%	0.00%
Labs	3.12%	4.35%	16.00%	21.05%	0.00%	0.00%
Online	28.12%	23.91%	24.00%	26.32%	14.29%	33.33%
Rotation	50.00%	41.30%	34.00%	36.84%	42.86%	0.00%
Self-blend	9.38%	6.52%	8.00%	0.00%	0.00%	66.67%

Figure 17 - Bloom's (Online) level vs learning approach (normalization by column)

Blooms_Level_Online Learning_Approach	Remember	Understand	Apply	Analyze	Evaluate	Create
Face-to-Face	18.18%	27.27%	36.36%	0.00%	18.18%	0.00%
Flex	5.56%	44.44%	27.78%	16.67%	5.56%	0.00%
Labs	6.67%	13.33%	53.33%	26.67%	0.00%	0.00%
Online	23.08%	28.21%	30.77%	12.82%	2.56%	2.56%
Rotation	25.81%	30.65%	27.42%	11.29%	4.84%	0.00%
Self-blend	25.00%	25.00%	33.33%	0.00%	0.00%	16.67%

Figure 18 - Bloom's (Online) level vs learning approach (normalization by row)

Recommendations

A set of recommendations was eventually defined starting from the lesson learned:

- A Learning Management System (LMS) should be identified and used as a repository for the material. The LMS can also be used for other purposes, such as redirecting to additional sources that interested students could use to deepen a specific topic if interested, or as a platform to practice theoretical concept and assess their learning.
- The content on the LMS should be properly organized, and professors should explain, since the beginning, the structure of the course and the aim of the activities, as well as the milestones in the course. This would allow students to understand the learning path that the professor defined and simplify finding the needed material on the LMS.
- The use of LMS should not be seen as a substitute for the F2F learning. Instead, a mix of the two should be used to provide students with practical experiences that can be then replicated remotely to evaluate their comprehension. In case students cannot participate in person to practical classes, it is useful to use the LMS to share recording of the practical session that can be viewed by students.

- After each milestone in the class, self-assessment quiz and/or exercise should be made available to allow students understanding their competence level and work to cover gaps and difficulties. Moreover, discussion forums should be made available to allow students to exchange opinions and help other students in solving their doubts. Also professors should contribute to the forum helping students. Feedback on the learning process should be provided by the professor through the self-assessment quiz, targeting students to the learning resources required to cover the gaps.
- The learning path should be structured with a controlled increasing difficulty, allowing students to secure the achievement of a concept before moving to the following one.
- Group work and problem solving/case-based exercises should be adopted to allow students practice what they learned and challenge them in further elaborating the content of the practice lectures. The group work should be designed to be as close as possible to a real situation, allowing student to comprehend the difficulties and challenges of real world problems. The group work should be targeted at favouring the discussion in between the students of the group but also with the professors, which should be available to guide students when needed.
- When video are used to support or complement the learning phase, their length should be under or equal to 10 minutes. Additionally, when multiple videos need to be watched, quizzes should be used in between a video and the following one to maintain a certain level of attention.
- Professors should collect feedback from the students on the quality and usefulness of the material provided, so that, if necessary, it can be improved

Suggested Readings

1. M. Mabkhot, Mohammed, et al. "Mapping industry 4.0 enabling technologies into united nations sustainability development goals." Sustainability 13.5 (2021): 2560.
2. Lupi, Francesco, et al. "Toward a sustainable educational engineer archetype through Industry 4.0." *Computers in Industry* 134 (2022): 103543.
3. Antonelli, Dario, et al. "Tiphys: an open networked platform for higher education on industry 4.0." *Procedia CIRP* 79 (2019): 706-711.
4. Maffei, Antonio, et al. "CONALI ontology. a framework for design and evaluation of constructively aligned courses in higher education: putting in focus the educational goal verbs." *Procedia CIRP* 50 (2016): 765-772.
5. Maffei, Antonio, et al. "On the design of constructively aligned educational unit." *Education sciences* 12.7 (2022): 438.
6. Sala, Roberto, et al. "Blended learning in the engineering field: A systematic literature review." *Computer applications in engineering education* 32.3 (2024): e22712.
7. Maffei, Antonio, and Fredrik Enoksson. "What is the optimal blended learning strategy throughout engineering curricula? Lesson learned during Covid-19 pandemic." *2023 IEEE Global Engineering Education Conference (EDUCON)*. IEEE, 2023.
8. Sala, Roberto, et al. "Examining the implementation of Blended Learning in the Engineering field." *5th International Conference on Higher Education Learning Methodologies and Technologies Online*. 2023.