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## Blended Learning and Problem Based Learning in a multinational and multidisciplinary setting

Pedersen, Jens Myrup; Lazaro, José; Mank, Lea; Eichhorn, Vanessa

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Guerra, Aida; Rodriguez, Fernando José; Kolmos, Anette; Reyes, Ismael Pena

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# 6th International Research Symposium on PBL

*PBL, Social Progress and Sustainability*

Edited by

Aida Guerra

Fernando José Rodríguez

Anette Kolmos

Ismael Peña Reyes



United Nations  
Educational, Scientific and  
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AALBORG UNIVERSITY

• Aalborg Centre for Problem Based Learning  
• in Engineering Science and Sustainability  
• under the auspices of UNESCO



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DE COLOMBIA

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Edited by Aida Guerra, Fernando José Rodríguez, Anette Kolmos, Ismael Peña Reyes

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# PBL, Social Progress and Sustainability

Aida Guerra, Fernando José Rodríguez, Anette Kolmos and Ismael Peña Reyes

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# Blended Learning and Problem Based Learning in a multinational and multidisciplinary setting

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## Abstract

The paper presents the results from the second year of the Erasmus+ Strategic Partnership "Collaboration and Innovation for Better, Personalized and IT-Supported Teaching", where seven universities and three companies work together on the joint course "Future Internet Opportunities" (5 ECTS). In the project and the course, we intend to tackle some of the major challenges we experience with university teaching today: An increasing number of students and more diversity among the students enrolled, an increasing pressure to ensure that the students are ready for the labour market after finishing university, and at the same time the challenges faced when it comes to adopting new technologies.

The course consists of two parts: A course module part with 10 modules, which provides the students with broad knowledge on "Future Internet Opportunities" from social, technical and business perspectives, and a project part where the students work in groups across nationalities and disciplines on real-world projects posed by companies.

This paper presents the evaluations carried out by all participating students, and discusses the experiences with the different learning components including different features of the Learning Management System Moodle, which was used for the modules. Moreover, it introduces the concept of just-in-time resources for Problem Based Learning, where we tackle the challenge of providing the students with methods and tools to be used in the projects just when they need it.

**Type of contribution:** Best Practice Paper

## 1 Introduction

The traditional university is struggling with both internal and external factors, calling for changes in the way we conduct teaching and design learning activities. In the first part, we will introduce some of the factors, and discuss how our approach of blended and problem based learning in a multidisciplinary and international setting can contribute to meeting some of the challenges we experience.

First, our universities are faced with an increase in the number of students who would previously not have chosen a university education. This tendency is especially outspoken in some of the more technical areas of engineering, where it has become hard to recruit students, often leading to a broad intake of students in order to satisfy the needs of the labour market. The challenge is not just to accommodate them in the universities, but also to make sure that they become as qualified for the labour market as those who would traditionally choose a university career. At the same time, there is a pressure to ensure that the students not only become skilled academics, but that they are also ready to take on the challenges experienced in the labour market after graduation, which requires not only good technical skills, but also collaboration

skills, project management skills, presentation skills etc. In other words, we need to educate students to solve problems rather than (just) equations (Walther et al., 2011), (Crawley et al., 2007), (Walther et al., 2007).

As a third point, traditional universities are being challenged by technology, and need to find their position in a world where Massive Open Online Courses (MOOCs) are becoming increasingly popular (Martin, 2012), and where even students in our own universities sometimes prefer to follow online courses rather than courses offered locally (Wulf et al., 2014), (Christensen et al., 2013). With the interactive, highly relevant, and professionally produced content of some of the courses, it is not surprising that a single lecturer giving a similar course cannot keep up to speed here – and often the use of new technology, including the many features of modern Learning Management Systems (LMS), is left to the individual teacher to explore and use. To address this challenge, universities need to define their own roles and value propositions, and decide how and for what virtual learning platforms and other technologies should be used. Lastly, also companies are dependent on good university education, as students are future employees. So, it is of interest for companies that students face real-world challenges already at university and that they get prepared for the labour market during education.

In this paper, we address these challenges through describing a new approach to learning, and the results achieved by trying it out in a joint course between seven European universities and three enterprises. We also present and discuss our experiences with different features of the LMS Moodle used for the course.

The paper is organised as follows: Section 2 provides an overview of our approach of the course, including a description of how the modules and projects are organised. In particular, we discuss the experiences from the first year of the project, and the changes for the following year as a result. Section 3 provides an overview of the evaluations and a discussion of what adjustments and changes should be made in the future. In section 4 we provide a discussion on the just-in-time resources for problem based learning (PBL) principle, and finish the paper with discussions in section 5 and conclusions in section 6.

## **2 Overview of the course**

The course is organised during the spring semester, and offered jointly by all seven universities. The overall theme of the course is “Future Internet Opportunities”. It consists of two parts: A course module part, which provides the students with knowledge on “Future Internet Opportunities”, and a project part where the students work in groups across nationalities and disciplines on real-world projects posed by the participating companies. After a virtual phase of module work, all students and teachers meet for one week (April) to finalise the module work and start the project work, and after a virtual phase of project work the participants meet for one week (July) to finalise the projects and conduct exams. The overall time plan is shown in Figure 1. In 2016, 30 students followed the course.

### **2.1 Initial timing considerations**

Timing the choices of modules, the formation of groups, and the distribution of projects is a puzzle with several possible solutions.

In the first-year edition of the course, the students chose modules based on interest, recommendations and requirements from local coordinators by the time of signing up for the course, and since students could choose up to four advanced modules, all modules had a fair number of students. For the projects, the groups were announced during the midway seminar (the groups were formed to reflect distributions in

background, modules, nationalities, and gender), and projects were randomly distributed between the groups.

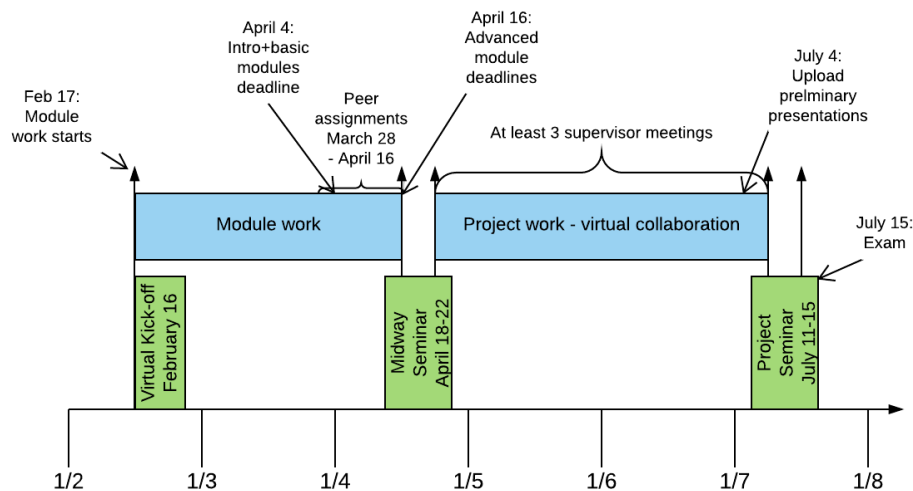


Figure 1: Detailed time plan of the course.

In the second-year edition, this scheme was revised to allow the students to get to know each other at an earlier stage, and to ensure that all groups covered all topics even with fewer modules for each student. The groups were already announced during the virtual kick-off meeting, and the selection of basic/advanced modules was coordinated in each group during the first weeks of the course. The projects were again announced during the midway seminar for several reasons: Announcing the project without the presence of company representatives and supervisors could lead to unnecessary misunderstandings and frustrations, and potentially, the students could start working in a wrong direction. In addition, the teachers again distributed the projects rather than letting the students select themselves. This was not done randomly, but based on a “matching” between student’s choices of modules and required/recommended modules for each project. The distribution approach ensures that all projects are chosen, and that not more than one group works on the same project, avoiding potential conflicts or disagreements.

## 2.2 Virtual kick-off

Starting a course that mixes virtual and physical mobility requires some considerations, one of which is whether to begin with a virtual meeting where all participants are present at the same time, or to simply “open” up the course. With the student groups being announced from the beginning, it was decided to have a synchronous virtual meeting with all participants being present, and use this opportunity to let the student groups discuss with each other (previous experience from last year showed that simply asking people to work together without facilitating some kind of introduction was hard). It was organised with four components:

- A presentation by the coordinator (transmitted in real-time by Adobe Connect).
- A presentation round, where each student would present himself/herself.
- A group quiz exercise, where each group had to coordinate their group work by themselves. Here the students were free to decide which conference/chat systems to use, however an Adobe System conference was setup for each group for those who would like to use it.

- A round with questions and answers.

Presentations and presentation rounds with multiple people distributed over 10 different physical locations was not easy to get to work with in a decent quality. Quality issues were also apparent here: Having discussions in this manner was difficult due to a combination of latency as well as varying audio and video quality among different participants. Moreover, it was hard to tell whether it was a local problem or system problem, and whether it was related to users (e.g. microphones not muted) or equipment (e.g. malfunctioning microphones). However, for a presentation that was mainly one-way, and for a short presentation round, everything worked out satisfactory.

For the group quiz, it needed to be considered whether the students should have more support/control and to which degree they should be left to their own. The Adobe conference provided an initial channel for everyone.

## 2.3 Modules

Each student follows 10 introductory, 4 basic and 2 advanced modules. This is based on a total workload for module work of 50 hours: Each introductory module takes around 1 hour, each basic around 5 hours, and each advanced around 10 hours. Compared to the first year, this second year implementation means doubling of the workload of each advanced module, which allows for more group work and peer learning activities included in advanced modules. The introductory modules are based on students interacting individually with the learning platform Moodle (Moodle, 2003), and the basic modules add more activities including assignments revised by the teachers. This seeks to increase flexibility (students can study many of the topics when they want, without a need for synchronisation) and reduce complexity as each student does not have to keep track of too many diverse tasks.

In the previous year, two things retarded the module work for the students:

- All modules were shown on the same page in Moodle, without the possibility for students to hide activities they did not have to undertake.
- No activity tracking was set up, so the student had to keep track of which activities he had done already.

In combination with not being the usual platform for most students, this made it hard for them (and for the teachers) to maintain an overview of which activities to undertake, and which had already been completed.

This was updated in the second year, so each student would only see the activities he/she should work on. Moreover, completion tracking was implemented helping students to keep track of their progress. However, completion tracking is not that simple to implement. In Moodle, two types of tracking (Zhang & Almeroth, 2010), (Hijón-Neira & Velázquez-Iturbide, 2006) are supported:

- The student marks an activity as completed manually.
- The system automatically marks an activity completed based on criteria, which can be specified depending on the activity.

When implementing this feature, the question arises whether it is a tool to help students monitor their own progression, or a tool for the teachers to be able to monitor the progression of the students. The answer might be that it is a bit of both. The manual approach has the obvious weakness that a student can easily tick all boxes, so that the activity seems completed (even if the teacher can see the timing of activities for each student). The automatic approach on the other hand suffers from the fact that it is hard to decide

when an activity is completed. For interactive elements such as a quiz, it works well, but for others (papers, watching videos etc.), an activity is completed when a student has watched it. This does not say much about completion, and for students who download or look through all materials before starting the module it offers little help in keeping the overview. Another consideration is which activities should be marked, for example when the same material is offered in different formats. In general, we tried to use the automatic approach, informing the students that they should themselves ensure the understanding of each part before moving on. In case of elective elements, manual marking was used.

Figure 2 shows an example of a typical introductory module, where the core is a combination of 5 – 10 minutes videos, and a quiz after each video. Besides there are some literature studies expected as well. Each module starts with introducing the learning objectives, and ends with a final quiz that marks the end of the module. While all students are required to finish all introductory modules before the deadline, it is not formally conducted as an exam, which would require a different technical/legal setup. So, at this stage it is very much a matter of trust (there is no control that the student is doing it on his own, and there is no limited number of attempts to finish the quiz) as the quizzes serve for auto-evaluation of the learning process.

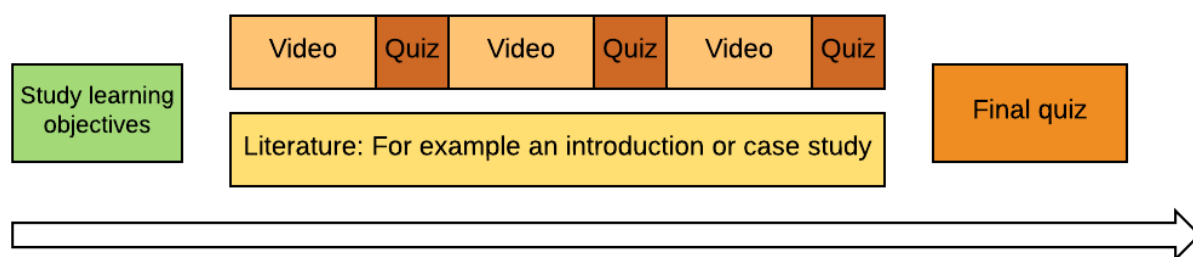


Figure 2: Example of an introductory module.

Figure 3 shows an example of a basic module. As in the introductory module, it starts with studying the learning objectives and ends with a quiz. The literature elements, video and quizzes can also be found. A Q&A forum is included for discussions and questions both among students and between students and teachers. One of the components in each basic module is a pre-module test, which allows students to check the prerequisites before starting the module, as well as pre-module materials that students can study if they need to top up their knowledge before starting the module (can be both materials created specifically for this, or pointers to relevant teaching material). The pre-module work is part of the individualised learning path, which allows students with different backgrounds to follow the same modules. However, it is still necessary to consider students' backgrounds: Creating this pre-module material might be more suitable for students with similar backgrounds, where some might lack knowledge of specific skills or tools. If background knowledge corresponding to years of studying in a specific domain is required, providing this would be out of scope for pre-module studies. Another consideration refers to the workload estimation: For whom is the workload estimation intended? Does it include pre-module material? And is it possible to design the full course with similar workloads for all students, when their backgrounds are so diverse? While it is tempting to say that the workload depends on the background of the student, it has to be kept in mind that the workload of a 5 ECTS course should be 150 hours for every student.

The advanced modules differ from introductory and basic modules since they include interactions between the participants in terms of group work and/or peer review tasks. Based on the previous experiences, this is a more challenging part since it requires more scheduling between the students, in terms of either virtual



meetings or deadlines for submission/reviews. This became quite complex in the last year when it was included in many modules in both basic and advanced levels (each with different deadlines and different students). For this reason, it is now limited to the advanced modules, and the deadlines are synchronised between the modules. Figure 4 shows an example of the structure of an advanced module.

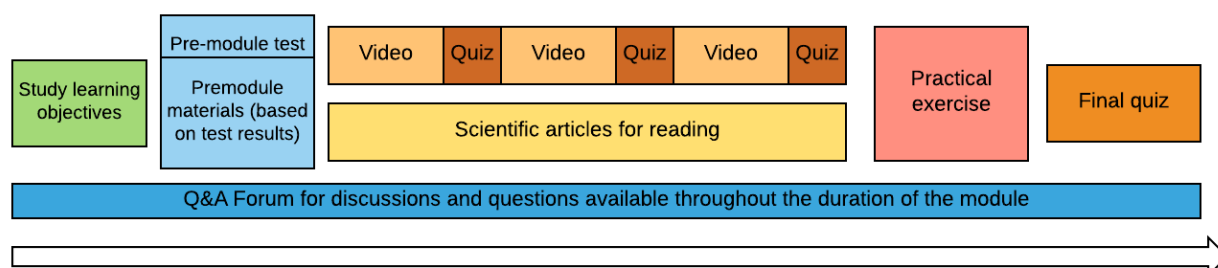


Figure 3: Example of a basic module.

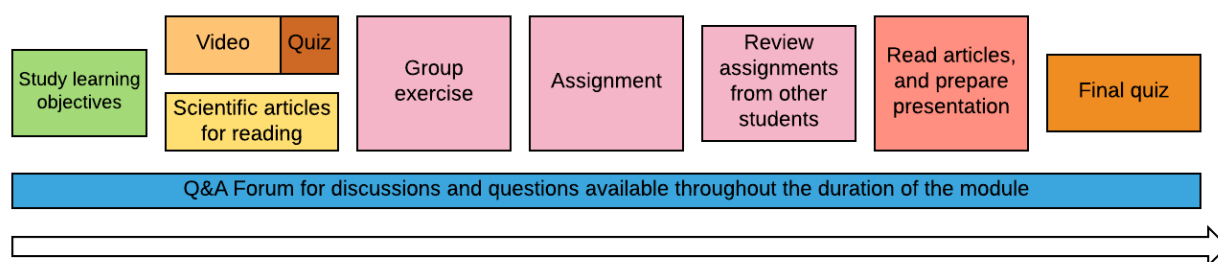


Figure 4: Example of an advanced module.

## 2.4 Midway seminar

Figure 5 provides a schematic overview of the seminars including the virtual collaboration phase. The idea behind the midway seminar is to synchronize the finalization of the course modules, and to start with the project work. During the first two days, time is allocated for a combination of introduction to group work and team building exercises. This boosts the social dynamics in the groups, which is important in order for the learning activities to work out well.

In the first year, the students followed a one-hour session for each basic and advanced module they took before, whereas in the second year the basic modules were more self-contained in Moodle, and with each student following fewer advanced modules it was decided to put more effort into finalising the advanced modules. Each student prepared a presentation of one of his/her advanced modules, and presented that for other students in a conference-like setting with two parallel tracks. This made it possible to finish the module's revision during the afternoon of the first day. Therefore, day 2 could already be devoted to focus more on group work, collaboration and project management – this was emphasized more than in year one, since the ability to work together as a group is an important foundation for the virtual collaboration that follows. This objective continued on day 3, where a workshop covered the topics of practical business development, to help the students to develop a business mind-set, and also to motivate and de-mystify the business aspects of the projects. This was set up in a way that would also bring the students closer together as a group.

With several different tasks and exercises, the question was whether to use the same groups for all activities (thus boosting their teamwork) or to vary the groups and to experiment with groups of different sizes to promote more social interaction processes across all the students, and let them experience different group dynamics.

During the last two days of the seminar the focus was on introducing the students to the projects, let them discuss with company representatives, and eventually come up with an initial problem analysis and a plan for the virtual collaboration phase. Compared to the previous year, the focus was more on structuring the forward work by providing the students with a description of the expected outcomes of the seminar (e.g. the initial problem analysis, time plan with mile stones and meeting plans), and to equip the students with relevant collaboration tools and templates for the virtual collaboration phase.

Throughout the seminar, there was a focus on training presentation techniques, both through a dedicated workshop and by video training sessions throughout the seminar. For example, each day ended with a “pitch talk” from each group, which was recorded and commented.

## 2.5 Virtual collaboration phase

During the virtual collaboration phase, the students worked on the real-world projects, receiving guidance mainly from their supervisors and company contacts. Examples of topics were: (1) how to develop a cloud-based Software-as-a-Service Threat Intelligence Solution, which could ensure that customers are protected from the volume and variety of cyber threats and (2) development of an easy-to-use bike-sharing platform for a German community, where the particular challenge was to make it more attractive to use the service compared to traveling by car, for example by developing an interconnected system easy to use (applications, interactive elements etc.).

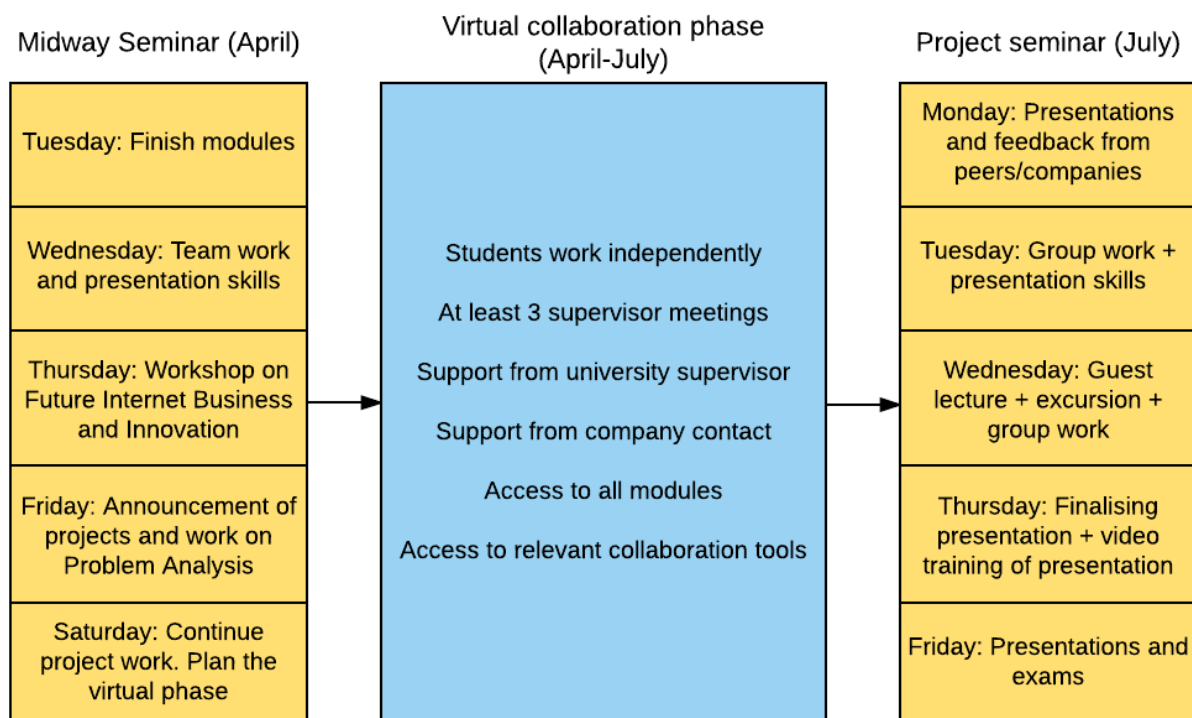


Figure 5: Schematic overview of seminars and virtual collaboration phase.

In the first year, this was a very student-driven process, but the experience was that for multiple reasons it was hard to get started: Students with different backgrounds have very different perceptions of what a project is and what roles supervisors and companies play. Working remotely can be challenging, and sometimes just coordinating a time to meet virtually can be difficult and delay the project – even more when organising meetings with relevant agendas and content. Letting the students decide on their own on the one hand, and steering the process through teaching/supervision on the other is another challenge. Last year at least 3 supervisor meetings were required, and students were asked to follow the time plan defined by themselves during the midway seminar for giving the course more structure. This also clarified the project and supervisor roles. Each group was required to send a report every second week to their supervisor to report on progress, and one student per university had to participate in virtual quality assurance meetings every third week and comment on the project progress. Moreover, the expected outcome of the virtual collaboration phase was clearly communicated to the students: A presentation of the project had to be uploaded at least one week before the project seminar, where they had to present it to a committee of company representatives, supervisors and fellow students.

## **2.6 Project seminar**

The focus of the project seminar is to help the students finish the project work and conduct examinations. During the first day, a number of peer seminars are held as described above. These sessions take place in parallel each with participation of two student groups, their supervisors and company representatives, where the students present their work and receive questions, feedback and suggestions from a wider group than their own supervisor and company representative. Much of the work during the next days is organised within the groups with the help from supervisors and company representatives. However, each day has one or more different themes, often supported by joint learning activities. At the end of each day, the groups give a small presentation according to this topic. The themes of the different days are listed in Figure 5.

One consideration refers to guest lectures and excursions, something that has been part of the course in the previous years. On one hand, it is nice to use the opportunity for all students being together to offer interesting guest talks, and it can divide what is otherwise a full day of work alone in the groups. The same applies to the excursion, which provides an opportunity to explore a relevant company/setting in the location of the seminar. On the other hand, at this stage, it is rather late for providing useful inputs to the projects, and some of the students feel under pressure because of project deadlines and examinations. However, we decided to make use of lectures and excursions in the last years and will also make it part of the next seminar in order to make the seminars more diverse and less exhausting. Moreover, offering a variety of activities makes the learning experience much more well-balanced, motivating and effective.

## **3 Evaluations and future adjustments**

The students were asked to evaluate all modules and projects through an electronic survey, both during and after the course, and to evaluate the overall course experience at the end. As the design of each module is different, it is hard to compare the different components between all the modules, but Table 1 summarises how many students of each module found the different activities to be either “Efficient” or “Very efficient” (the other alternatives were “Very inefficient”, “Inefficient”, “Neither efficient nor efficient”, and “Not used/applicable”). Full evaluations can be found in (Colibri, 2017). It is important to note that many of the low-scoring activities receive many (Not used/applicable).

It is clear from Table 1 that the students were generally happy with the overall modules of introductory, basic and advanced levels, and that components such as video lectures and questions/quiz material received quite good evaluations even with some room for improvements. The following comments reflect student's comments and observations by teachers to the other activities:

Table 1: Percentage of students of the 10 modules, who found that part to be "efficient" or "very efficient" for their learning experience.

| Module number                                  | 1  | 2  | 3  | 4  | 5   | 6  | 7  | 8   | 9  | 10 |
|--|----|----|----|----|-----|----|----|-----|----|----|
| Introductory level                             | 89 | 97 | 72 | 80 | 86  | 89 | 73 | 92  | 73 | 89 |
| Video lectures                                 | 62 | 82 | 72 | 65 | 72  | 79 | 73 | 96  | 55 | 79 |
| Questions/quiz material                        | 72 | 76 | 69 | 63 | 79  | 80 | 79 | 86  | 59 | 79 |
| Q&A Forum                                      | 31 | 34 | 20 | 21 | 31  | 31 | 28 | 35  | 31 | 28 |
| Self-study activities                          | 55 | 55 | 52 | 45 | 58  | 51 | 58 | 76  | 45 | 75 |
| Basic level                                    | 88 | 80 | 88 | 87 | 100 | 70 | 76 | 100 | 75 | 93 |
| Peer learning activities (advanced level only) | 13 | 84 | 14 | 43 | 57  | 25 | 25 | 0   | 38 | 78 |
| Advanced level                                 | 40 | 84 | 86 | 72 | 85  | 50 | 80 | 100 | 88 | 78 |

Q&A and discussion forums have been launched for all basic and advanced modules, but only used to a very limited degree. At least two factors contribute to this: First, a technical issue, which makes it impossible to send out email notifications using the participants usual email addresses. This means that students are unaware of forum activity, unless they actively check for it – thus, the few topics posted received only little attention. Second, because discussions were not often actively initiated or encouraged by the teachers, e.g. by providing discussion topics or by building into exercises that the students should discuss certain topics. Those points are important to keep in mind for the next edition of the course. The self-study activities received a high number of "Neither effective nor ineffective". It was not always sufficiently clear defined what the students were supposed to do, and when an activity could be considered completed. For example, if students are asked to read a paper, but no follow-up in terms of assignments or exercises are submitted, it becomes easily confusing. The need for precise instructions is particularly important when most of the learning is online and without the possibility for discussions between teachers and students. For the peer learning activities (Boud et al., 2014), (Boud et al., 1999) the relatively low scores were surprising. Based on the comments received, and discussions with students after seeing the results, it became clear that many students were not aware of what peer learning is, and therefore rated as "Not used" or "Neither inefficient nor efficient". For the tasks where students need to work in groups, it is important to facilitate this (e.g. announce the groups well in advance, and explain exactly what they should do and how they should collaborate). With the relatively tight time constraints in the module phase, some students did not manage to coordinate even a meeting time. Again, the most important learning point is to be very clear about what the students are expected to do, and to make sure that the students know what the term "peer learning" covers. Generally, for the course part, it is important that it is very clear what the students are supposed to do, something which is supported also by the completion tracking. However, as discussed in the previous section, using completion tracking is not without challenges. After the course was completed, the technical platform in Moodle has been improved. One element is dependencies, so that

some activities cannot be accessed before previous parts have been completed. This is something that will be tested out during the coming year.

The projects were evaluated in a similar way, and the results can be seen in Figure 6. The most important point to work with is the virtual collaboration. Next year, even more focus will be on facilitating this, through better preparation of the students in the midway seminar, through providing a better platform for the collaboration, and through a more systematic support from supervisors during the phase.

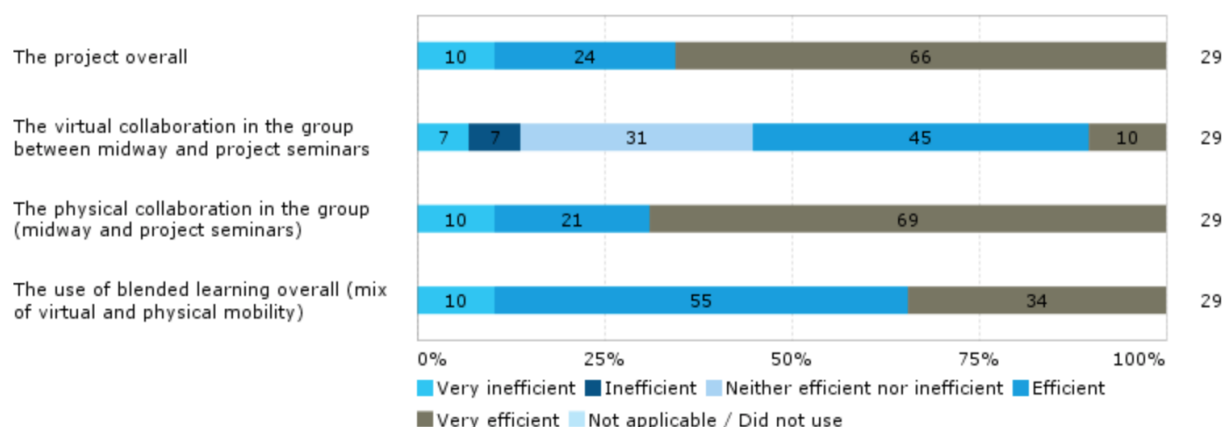


Figure 6: Students' responses to the question: Please rate how efficient the following parts of the project have been for you with respect to learning.

The course was also evaluated as a whole. The students' evaluation of the impact on them is shown in Figure 7. Overall, this supports the conclusion that the teaching methods tested out contribute to solve the issues listed in the introduction of the paper.

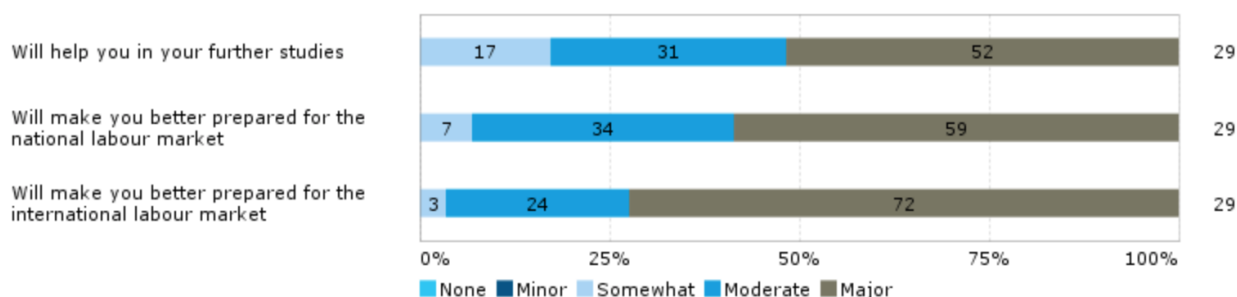


Figure 7: Students' responses to the question: Based on your personal outcome from participating in Colibri, please assess to which extend the teaching methods used in Colibri impact the following.

#### 4 Just-in-time resources for PBL

We observed that the online/interactive material from the modules was used during the project phase, and that this gave a good support for the project work. These observations led us to develop a model for just-in-time resources for PBL, which can be beneficial also in more traditional PBL teaching situations.

The initial project design was based on first studying the modules, then doing the project work. This is adapted from classical PBL models (e.g. the Aalborg model), where courses take place in a traditional manner that requires all students to take the course at the same time. With the online modules, it provides

much more flexibility as it makes it possible for students to follow relevant parts of the module when they need it, so that (1) the students are very motivated because they know what to use the knowledge for and (2) it allows for efficient learning because the students get to use the knowledge to solve a real problem.

Figure 8 shows the model we have developed. The first step is that the students need to analyse their problem, and obtain some initial knowledge. When students then work on the project, this initial knowledge can be used to identify which methods/tools could be relevant to use, of course also with the assistance of supervisors. The material is not limited to that of the modules, but could also come from many other sources. After having solved one problem in the project, the cycle continues with other problems.

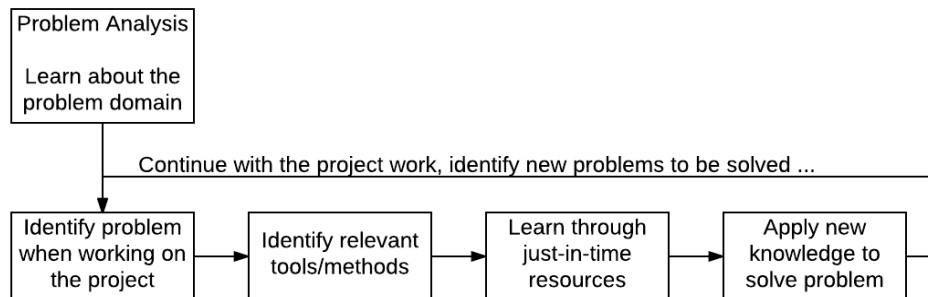


Figure 8: Just-in-time resources for PBL.

## 5 Conclusion

This paper presented how blended and problem based learning can be combined in a multidisciplinary and multinational setting, and we demonstrated how we handled the most important challenges in the course, i.e. the different technical backgrounds of the students, the diversity in educational culture/background, experiences with project work, and the challenges when most of the work was done remotely.

Based on the feedback from students, the course was successful and especially the work on real-world problems in diverse and international groups of students was highly appreciated. In the future, it would be an advantage to focus more on the group work and project management during the midway seminar, and also to have a more structured process during the virtual project work – something that could also be supported by using a more suitable collaboration platform, which is one of the changes we will do for the next run. The online module material was also evaluated positively, even if there is room for improvements especially when it comes to self-study activities, Q&A forums and peer learning. Especially the comments from the students regarding “peer learning” show that it is important to explicitly explain the students the learning activities and the thoughts behind them, especially when working with diverse groups of students who come from different educational cultures and habits. The paper also introduced the concept of just-in-time resources for PBL, where online material is made available for students to access during their project work: This provides students with knowledge and skills just when they need it, increasing their motivation as well as their learning process since their new knowledge is applied to a real case straight away. This also demonstrates the potential of combining problem based learning with virtual learning platforms. It is still a young movement and there is further investigation needed on how to implement it in the best possible way; especially when it is integrated in the project work.

Based on the results achieved, it is clear that there is a potential in working further with the methods proposed in the paper. When doing so in the future, we will address the points identified above and work further on implementing just-in-time resources for PBL.

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