USING ACTIVE LEARNING IN HYBRID LEARNING ENVIRONMENTS

C. Demazière

Chalmers University of Technology
Department of Physics, Division of Subatomic and Plasma Physics
SE-412 96 Gothenburg, Sweden

demaz@chalmers.se

1. BACKGROUND

With overall declining student enrolments in nuclear engineering programs in Europe, being able to maintain highly specialized courses alive has become a challenge. As a possible remedy to such a situation, efforts have been pursued at Chalmers University of Technology, Gothenburg, Sweden to offer short courses in "hybrid" learning environments. In this paper, a hybrid environment is defined as a learning environment that combines on-site and off-site attendees while preserving full interaction possibilities between both audiences and between each audience and the teacher. Although there is no formal limit between how many on-site versus off-site students there should be, the incentive of the course offering would still be to attract as many as possible on-site attendees, so that synchronous interactions are face-to-face and thus more natural.

In order to make this possible, a special interactive teaching room was developed at the Department of Physics and allows both audiences to share audio, video and digital contents [1]. This room is furnished with movable chairs, tables and whiteboards, also enabling the use of a more student-centered pedagogical approach. In addition, the room is equipped with audio and video hardware and software. The core of the system is driven by a high-end tablet PC running web-based conferencing tools and connected to the room hardware. The audio/video equipment allows synchronous interactions between the on-site and off-site participants in form of digital content sharing, audio interactions, and video communication.

Beyond the design of the room, emphasis was put on favouring student learning, building upon the use of active learning techniques. Active learning techniques were demonstrated to lead to much better learning outcomes and to contribute to a deeper approach to learning compared to traditional teaching approaches [4]. In order to maximize the time when the teacher and the students meet, either face-to-face (for the on-site attendees) or on the web (for the off-site attendees), a flipped classroom pedagogy was followed [2, 3]. In the flipped classroom model, students are asked to do some preparatory work before attending the in-class sessions. In this asynchronous learning phase, the students can choose when and at what pace to study the preparatory course material. The time spent with the teachers can then be used more effectively to engage students in more active forms of learning.

Nevertheless, designing activities favouring student engagement is particularly challenging in hybrid learning environments, when both on-site and off-site audiences are mixed. This paper reports on two short courses arranged along the lines above and assesses the efficacy of the synchronous sessions in terms of student engagement, based on both the teacher's and the students' perspectives, for the latter using anonymous course evaluation questionnaires.

2. METHOD AND RESULTS

The above pedagogical set-up was applied to two short courses: a course titled "Fundamentals of reactor kinetics and theory of small space-time dependent fluctuations in nuclear reactors" offered as part of the European Horizon 2020 CORTEX project (CORe monitoring Techniques and

EXperimental validation and demonstration) [5], and a course titled "Deterministic modelling of nuclear systems" offered as part of the European Horizon 2020 ESFR-SMART project (European Sodium Fast Reactor Safety Measures Assessment and Research Tools) [6].

Both courses were given as "flipped" classes. The entire pedagogical approach used in the two courses is summarized in Fig. 1. The students had first to study the textbooks specifically written for each course. Short lectures or webcasts associated to each of the sections of each chapter were also recorded and made available to the students. Those lectures aimed at extracting the most important features presented in the respective textbooks in order to help the students construct a hierarchical and conceptual understanding of those features. The details of the derivations were presented in the textbook and left for self-studying. The lectures were recordings of lecture slides accompanied by the oral narrative from the teacher and with on-screen annotations made by the teacher. On-line quizzes were also associated to each of the webcasts, in order to provide formative feedback to the students on their learning. The webcasts and on-line quizzes were made available online using a platform called Chalmers Play, itself based on the Kaltura platform. Those three first moments, i.e. study of the textbook, attendance of the webcasts, and training on the on-line quizzes, represented the preparatory work the students had to complete prior to attending the in-class sessions (either on-site or off-site). Only asynchronous interactions between the teacher and the students were possible during those three first moments. Synchronous interactions were made possible during the in-class sessions, using remote conferencing/webinar software (Adobe Connect for the first course and Zoom for the second course).

For the CORTEX course, those synchronous sessions included short summarizing lectures or wrap-ups, discussions on the quizzes, and exercises requiring theoretical derivations led by the teacher. For the ESFR-SMART course, wrap-ups were also part of the synchronous sessions. In addition, the core of the active learning sessions was set up around solving various programming assignments in MATLAB Grader under the guidance of the teacher.

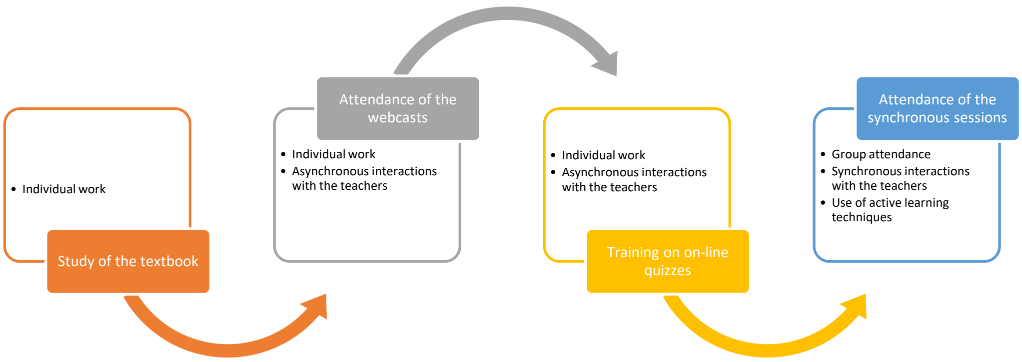

Fig. 1 – Summary of the pedagogical approach.

In the CORTEX course, the active learning technique that was used was group problem solving, a subcategory of collaborative learning. The students were put in groups of three or four, and they were assigned a task, question, or problem to solve together. All groups were assigned the same exercises. The problems were of the "pen and paper" type, i.e. the students were asked to write down some theoretical derivations to find the answers to the problems. After being provided with instructions from the teacher, the students had to solve each of the problems. This was done in a collaborative manner between the students, as well as with the teacher, i.e. the teacher provided additional explanations and theoretical considerations when needed. The exercises were solved one after the other, i.e. the students were asked to complete each assignment at a pace dictated by the teacher. This allowed the teacher to also build upon each assignment, provide complementary information and most importantly relate the theoretical derivations to practical applications. Discussing the outcomes of each assignment was fundamental in capitalizing on the gained knowledge and soliciting high order thinking skills among students.

In the ESFR-SMART course, the active learning technique that was used was also based on group problem solving, although in the completely different set-up. Namely, coding assignments had been prepared by the teacher. Each coding assignment focused on some specific part of the textbook and the students were thus asked to implement the numerical techniques and algorithms to a practical case. In total, the students had to go through seven coding assignments. All coding assignments were carried out in MATLAB Grader, which is a web-based platform allowing the students to complement some MATLAB codes, test those, and submit their solutions when all tests were successfully executed. Because of its web-based nature, MATLAB Grader provided the exact same coding environment to both the on-side and off-site attendees. A 30 day-free trial version of the full desktop version of MATLAB was also provided to all students, in case they had not already access to MATLAB. The full desktop version of MATLAB gave much more flexibility as compared to MATLAB Grader in case the students wanted to further test their codes.

The CORTEX course was given on June 18-21, 2018 and had 16 on-site and 26 off-site registered participants, whereas the ESFR-SMART course was given on September 9-13, 2019 and had 22 on-site and 39 off-site registered participants. As customary when offering courses free of charge, not all registered participants did actually come on site or did participate to the courses remotely. In terms of on-site attendance, the first course attracted 14 students, while the second course attracted 11 students. All the on-site attendees successfully completed all in-class assignments and obtained a course certificate. Since the remote students had the possibility to either work on the in-class assignments and correspondingly obtain a course certificate or only get hold of the course materials, no strict control of the participation of the remote attendees was carried out. Providing the actual number of remote attendees following all course moments is thus not possible. Nevertheless, a careful check of the completion of all in-class assignments by the remote attendees wishing to obtain a course certificate was carried out. The remote attendees who obtained a course certificate amounted to 10 students for the first course and to 16 students for the second course. In both courses, the audience was mixed: MSc students with a solid background in nuclear engineering, PhD students and Post-Doc students in nuclear-related subjects, nuclear engineers and research scientists. Both courses were worth 1.5 ECTS (European Credit Transfer System).

In both cases, the teacher's impression was that the students were deeply engaged in solving the various assignments, discussing those with their peers and with the teacher. For the teacher, it was furthermore extremely rewarding to be able to help the students when they most needed help. Solving the assignments also triggered numerous questions from the students. Although some of the questions were directly related to the assignments, some other ones were of much more general nature. Even though students tend to underestimate their level of learning in more active forms of learning [7], the level of the questions put to the teacher, of the discussions held and the completion of the assignments demonstrated that the students learned much better in this teaching format with a deeper learning of the subject. This subjective assessment of student learning would nevertheless need to be substantiated by more quantitative measures using a control group of students given the same assignments in a more classical teaching format.

For both courses, an identical course evaluation questionnaire was used at the end of each course. For the first course, 23 persons responded to the course evaluation, out of which 52.2% were on-site participants. For the second course, 25 persons responded to the course evaluation, out of which 40% were on-site participants. Several questions were related to the pedagogical format. In the following, only one question is reported. Namely, the participants had to estimate how engaging the synchronous sessions were. As can be seen in Fig. 2, the students overwhelmingly considered that the synchronous sessions were engaging (with a vast majority in the second course considering that the sessions were very engaging). A closer examination of the additional comments provided by the students demonstrated that, for the first course, dialogue with the teacher was somehow limited. This was explained by the fact that handling both the questions from the remote and on-site attendees represents a very challenging situation for the teacher, especially when the questions from the remote attendees are numerous and come from several sources (audio communication, chat room, Q&A). To circumvent this difficulty, help from a teaching assistant was obtained in the second course. The main responsibility of the teaching assistant was to handle the communication with the remote students and help those students if need be. Having an additional resource in the second course might explain the increase in student engagement.

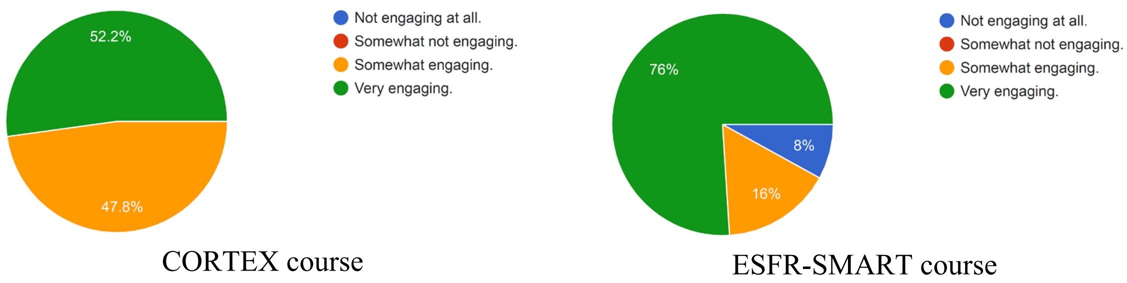

Fig. 2 – Engagement in the synchronous sessions.

3. DISCUSSION AND CONCLUSIONS

Despite the hybrid format of the offered courses and compared to a traditional teaching format, the proposed set-up led to much more interactions between all parties involved.

The flexibility with the hybrid format and with self-paced learning thanks to the flipped classroom makes the course offering particularly attractive to students who do not have the possibility to travel and to industry representatives who cannot always come on-site to follow a course. In addition, the 24/7 availability of the recorded lectures and electronic resources is an aspect making this teaching format particularly well suited for continuous education of staff members and life-long learning.

It should nevertheless be mentioned that the development of such a hybrid course with such a pedagogical concept requires careful preparation and planning, and foremost, dedication from the teacher undertaking such a radical transformation. In addition to the necessary time and required efforts, the technical and administrative frameworks in place at the respective university might not be adapted to the teaching format. Moreover, many IT resources are required, such as a streaming platform for the webcasts, a platform for the quizzes, a platform for the remote synchronous sessions, and a platform for e.g. the coding assignments. Learning all those resources and obtaining the necessary help from the competent/responsible persons might also represent some additional complications and create some additional delays when setting up all those electronic resources. Furthermore, because of the asynchronous nature of most of the resources being made available to the students, those resources need to be ready well ahead of the synchronous sessions. Thorough testing of those resources is also necessary before they are made available to the students.

Despite the challenges of using a hybrid learning environment, this innovative concept might represent a viable alternative to either fully on-site or fully web-based courses. This is particularly interesting when a critical mass of on-site students cannot be gathered.

The course set-up described in this paper allows combining a student-centered pedagogical approach and different audiences, while still preserving full interaction possibilities between the on-site attendees, off-site attendees and the teacher. The proposed set-up can easily be generalized to other areas of engineering education. If an adequate number of teaching assistants is available, the format could be scaled up to much more students, both on-site and off-site.

4. ACKNOWLEDGMENTS

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