Reacting to COVID-19 campus imminent closure: Enabling remote networking laboratories via MOOCs

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***Abstract*—The concept of Massive Open Online Course (MOOC) brings the opportunity to adjust both the study content, and the context, based on the teaching needs. Therefore, in this paper, we present our best practices on enabling remote networking laboratories via Blackboard platform, including the Blackboard Collaborate Ultra extension, in order to efficiently react to the challenges of imminent campus closure imposed by COVID-19 breakout. We present an extensive survey as a feedback from students, which allowed us to measure and to quantify students' experience and satisfaction with the remote teaching setup that successfully served 45 enrolled students. As the results bring the positive attitude towards practices presented in this paper, such teaching practices will foster some of the critical skills nowadays, such as collaboration, self-driven learning, and problem solving, and they can also serve as a successful example on how to efficiently cope with the limited access to traditional classroom resources within various courses.**

I. Introduction

A significant effort is invested in exploiting the Information and Communications Technologies (ICT) for providing the support to education during the last two decades [1]. Accordingly, numerous Learning Management System (LMS) solutions, such as Blackboard, Moodle, etc., emerged to serve as an auxiliary setup for the teaching and learning processes. For instance, the research conducted at the Hubei University of Education in 2018 provides opportunities for using e-learning platforms to enable blended learning as an important concept, which brings flexibility, smartness, and ease of access to higher education [2]. Furthermore, the Massive Open Online Course (MOOC) practices deliver the content in a dynamic, massive, and learner-centric manner, so the creation of the content for the students is shaped based on their learning participation, and collaboration with the lecturers, and the teaching assistants. Therefore, following the MOOC concept of generating a study content and context adjusted to the learning, and the teaching needs, we present our teaching practices for creating a remote teaching module via Blackboard (BB), to efficiently respond to the challenges imposed by campus closure. Thus, our approach represents a comprehensive module that uses MOOCs to both delivering lectures and having hands-on remote laboratories within the confines of the course Distributed systems. For the latter we combine the MOOCs with remote laboratory technologies that leverage cloud systems, as presented in [3]. In this paper, we thoroughly present and analyze the students' feedback that allowed us to measure and quantify their experience and satisfaction with the remote teaching setup. Such setup at the University of Antwerp, Belgium, has successfully responded to the instant campus closure caused by the COVID-19 situation.

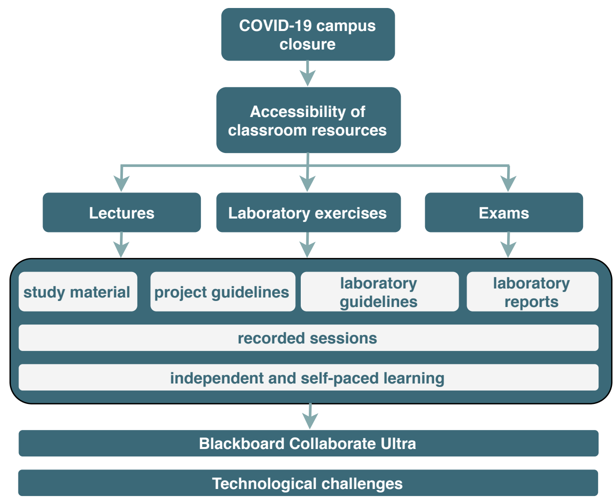

Fig. 1: The structure of our comprehensive approach towards enabling our remote networking laboratories via MOOCs.

By having a full licence for the software, we utilize a BB Learn platform for the wide variety of purposes, such as providing a study material, recorded lectures, laboratory sessions, and seminars, publishing the important announcements for the students, massive communication, personal communication, etc. (Fig. 1). Furthermore, for the online teaching, and the interaction with students, we adopt the BB Collaborate Ultra extension, which allows lecturers/instructors to efficiently perform all the teaching activities.

One of the main motivations for creating such easy accessible teaching module is to enable a large group of students to access the classroom resources (e.g., study material, guidelines for the project, laboratory sessions and reports, etc.) in an unrestricted manner. This way, the teaching activities are not negatively affected in case no physical access to classroom is possible. Another important advantage of enabling the remote classroom via MOOC is the opportunity for students to set their own learning pace, by allowing them to access the pre- and post-recorded lessons. In addition to lecture recordings, the corresponding study material can be posted prior to all teaching activities so the suitable preparation for the online lessons can be made. As a practical compound of our course, we perform laboratory exercises in which the teaching assistants present to all of our 45 enrolled students the topics that will be covered by different student tasks, and then create breakout groups that gather students who work in a team on the project within the course.

Despite the benefits of such teaching approach, there are some challenges that affect the teaching process. Since the students are not physically present in the classrooms while performing their tasks, or following the lectures, it is challenging to timely monitor their learning curve. Students also need to work more independently, or invest efforts to increase the level of collaboration among students in a group. There are also some other challenges, such as insufficient digital competences, network connectivity issues that imply inability to share the screen, or follow the content, among others. Thus, it is utmost important to inspect the students' experience with the concept of enabling the remote classroom via MOOC, thereby identifying the potential gaps in teaching techniques, which can be finer tuned and tweaked based on the identified needs.

Due to the positive attitude that students expressed towards our teaching practices, and their overall success at the end of the academic year, the practices that we present in this paper will foster some of the critical skills nowadays, such as collaboration, self-driven learning, and problem solving. Finally, these practices also serve as an example on how to quickly and efficiently incorporate similar approach to various courses.

II. Related work

In their survey, Pishva et al. [4] study how BB is assisting educational institutions around the world, forecasting that it will continue dominating the LMS market due to its positive impact on the educational outcomes. One of the first attempts to incorporate BB into education is presented by Hicks [5]. At that time, BB was used only for making the study material available at the course page, but it was evaluated as beneficial for increasing the depth of understanding the subject matter [5].

Although no feedback is collected from students, Zheng [6] presented the practices of incorporating BB in a computer programming course. As a part of this research, several aspects were analyzed, such as publishing information and course materials, monitoring the students' progress, and constructing online communication platform. Measuring the time students spent using the BB content, its incorporation into the course was justified, and proved to be reasonable.

In his attempt to assess students' experience with using different LMSs, i.e., Yahoo Groups and BB, Hamade [1] identified some of the key goals of using LMS in education, such as: i) improving students' learning experience, ii) supporting teachers' efficiency by decreasing the amount of repetitive tasks, and iii) improving the quality of study content and representation. The surveying procedure measured the general usefulness of the program, and its integration into the classroom environment. The results indicate that prior to using BB, students should be familiar with Yahoo Groups or similar platforms, due to the necessity of possessing certain digital competences as a prerequisite for using BB. This survey was structured to evaluate the LMS, but not to inspect the particular impact of specific features, or system's responsiveness to the massive enrollment, and unexpected teaching circumstances.

The use case presented by Al-Omar [7] is one of the examples that show how incorporating LMS or MOOC concept into the education is not enough per se, but it also requires a careful design of the courses in order to positively affect students' learning process. The negative results that were obtained in his study show that less efficient organization of the content on the course websites highly affects students' perception and learning experience.

In this paper, we present how our teaching practices in a comprehensive remote teaching module address challenges imposed by campus closure, by studying a thorough feedback collected from students. Alike the aforementioned approaches, this extensive feedback evaluates the impact of various BB features on the learning experience, providing the guidelines to efficiently identify the gaps in remote teaching, and to address the challenges by adjusting the content of the lectures/laboratories *on-the-fly*, thereby tuning the teaching pace according to students' needs.

III. Teaching practices in a remote module enabled by MOOCs

The teaching practices of enabling the remote teaching module via MOOCs are developed for our course Distributed Systems[1], which is in the final year of Bachelor studies within Electronics and ICT Engineering Technology program, at Faculty of Applied Engineering, University of Antwerp, Belgium. Following the general guidelines for the course, students are expected to have a knowledge of use of computers and Internet, but also a minimum of programming skills to be able to create adequate software solutions. During the full semester, the lectures are followed by laboratory activities, thereby preparing students with a satisfactory amount of information needed to properly understand tasks within practical exercises.

A. BB Learn and BB Collaborate Ultra for Massive Remote Teaching

As a massive learning management system, University of Antwerp adopts a BB Learn, a widely utilized platform for the

[1]The description of the module: https://www.uantwerpen.be/popup/opleidingsonderdeel.aspx?catalognr=1515FTIDSS&taal=en&aj=2020

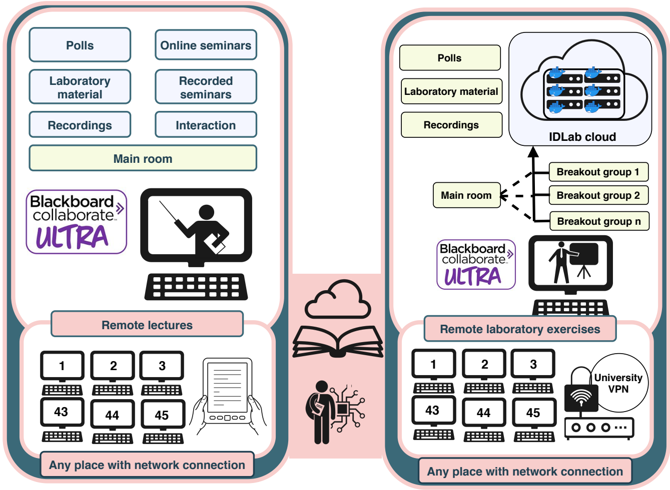

Fig. 2: A comprehensive remote teaching module enabled by MOOCs.

purposes of online learning. Since the campus closure occurred this year during the COVID-19 pandemic, all University courses switched to their virtual classrooms using an extension to BB Learn, i.e., a web conferencing tool BB Collaborate Ultra.

BB Learn[2] is a web-based application for online teaching, learning, community building, and knowledge sharing, which we used as a supplement to traditional face-to-face courses even before the campus closure. All instructors who are involved in teaching a particular course are given the instructor permissions to upload, organize, change, and remove, all the study material from the course page. Thus, for each course there are plenty of options that lecturers can use to interact with students in a synchronous, or an asynchronous way. Before the campus closure, our experience was bounded by asynchronous activities that involved organizing an online syllabus, opening the discussion items with students, performing online activities such as collecting students reports, or sending bulk e-mails to all entities with a specific role. However, due to the COVID-19 outbreak, an immediate reaction towards enabling the remote teaching was initiated at the University. For that purpose, all instructors shifted to remote teaching via BB Collaborate Ultra, which empowered us to perform both the lectures, and the laboratory sessions, in an interactive, and efficient manner that is paced according to students' needs.

B. Our MOOC-based remote classroom

As illustrated in Fig. 2, our comprehensive remote teaching module enabled via MOOCs consists of two main groups of activities, i.e., lectures (left side of the Fig. 2), and laboratory sessions (right side of the Fig. 2). Both activities can be followed by any student who is enrolled in the course. If we consider a situation in which we have a boosted enrollment of students, in case teaching is performed in a traditional in-classroom environment, it is expected that a significant amount of new resources (e.g., desks, computers, larger classrooms, double sessions, etc.) must be assured in order to efficiently handle the workload. In parallel, the online teaching to which we switched allows us to use a highly scalable platform that can respond to massive enrollment, and massive large-scale interaction during online lessons. Due to the COVID-19, the decision for upcoming year is to adopt blended learning concept, by holding certain number of students physically at the lecture room at University, while providing remote teaching setup for the rest of them. Therefore, our flipped material is critical in order to provide a homogeneous experience to these two different groups of students.

Concerning the practices regarding lectures, students can join the classes from any suitable place with internet connection. The lecturer uses mechanisms of sharing screen to present the material, and to trigger the discussion with students. One of the ways to interact with students is possible through Polls, which is an embedded BB Collaborate functionality that lecturers can organize to quickly get a feedback from students. Such instant feedback helps lecturers to identify the gaps in the students' knowledge, as well as the teaching process, and to address them properly.

This year we also opted for online recorded seminars, which students should prepare, record, and send to the lecturer, instead of presenting during the allocated sessions. Such practice saves a valuable amount of time that can be further used for working on the project, or studying.

Tackling laboratory sessions, teaching assistants use breakout groups, in which students can work on the project together with their colleagues from the group, digitally interacting among themselves, and minimizing the impact to/from other groups. This concept of breakout groups mimics the realistic feature of teamwork that we tend to encourage during the students' work on the projects with the course of Distributed Systems. Regarding the project work, students' main task is to build a distributed file sharing system among nodes that are organized in a circular topology. Before the lockdown, students were supposed to develop such distributed system by using Raspberry Pis (RPis) [8]. However, such circumstances implied the need for shifting the whole laboratory to the cloud, thus, instead of utilizing RPis students were instructed to use virtualized environment in the form of Docker containers. Such laboratory setup is presented in the top right corner of the Fig. 2. Instead of five RPis, each student group gets a cluster of five Docker containers that share IP address, but receive the upcoming requests on different dedicated ports. The teaching assistants are enabled to monitor the cloud machines used by students, and to track their progress, using the Portainer container management platform. Students have no restrictions on work out of scheduled hours, and they are encouraged to manage their own time and work on the project. More details about this approach can be found in our previous work [3].

Throughout the semester, teaching assistants can create polls in order to clarify the project tasks, to resolve potential doubts that students might have concerning the project functionalities. This way the activity and students' involvement can be tracked,

[2]Blackboard Learn documentation: https://help.blackboard.com/

TABLE I: Statements about Lectures (L) and Laboratory exercises (LE)

L	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Remote classroom is suitable replacement for a traditional one.
S2	I feel comfortable interacting with lecturer during online lectures.
S3	Network connectivity issues block me from grasping the matter.
S4	I easily lose focus during remote lectures.
S5	Preparing for remote lectures is more efficient.
LE	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Remote lab is suitable replacement for traditional one.
S2	I feel comfortable interacting with teaching assistants.
S3	Network connectivity issues affect interaction with assistants.
S4	Assistant's physical absence affects understanding of lab material.
S5	Breakout groups are suitable substitution for a team work.
S6	Assistants efficiently handle the management of breakout groups.
S7	I am satisfied with the promptness of assistant's feedback in breakout groups.
S8	Remote interaction with my teammates was satisfactory.
S9	I would work harder and more efficiently in a physical lab.
S10	Remote hands-on work positively affected learning.
S11	I can use time more efficiently while working on the project in a remote environment.

TABLE II: Statements about Polls (P), Study material (SM), Seminars (S), Interaction with Students (I), and Recordings (R)

P	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Short polls were clear and unambiguous.
S2	Short polls helped me to better understand the matter.
S3	Short polls helped me to detect the misunderstanding.
S4	I feel comfortable participating in polls.
S5	Polls are good practice in general.
SM	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Study material on Blackboard (BB) is efficiently organized.
S2	Material is uploaded in a timely manner.
S	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Recording seminars is suitable and time-efficient.
S2	I feel more comfortable preparing and presenting the seminar offline.
I	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Uploading material on the BB is more practical than distributing it via e-mail.
S2	Important announcements are delivered to students in a timely manner.
R	*Please evaluate the following statements from Strongly Affirmative to Strongly Negative.*
S1	Recording lectures is a generally useful practice for all courses.
S2	I take advantage of the recorded sessions while studying.

and evaluated.

With the remote teaching via BB, and remote lab setup created in the cloud, students were enabled to gain various skills, and to acquire different experience throughout the semester. Thus, it motivated us to design a thorough survey in the way presented in the following section, and to inquire students to evaluate their experience with particular components of such remote teaching via MOOCs.

IV. Analysis of students' feedback

In order to measure students' experience with our remote teaching module, and to evaluate their satisfaction with new teaching practices, we have conducted an extensive survey that tackles all constituent elements of our remote teaching module, such as: i) lectures, ii) laboratory exercises, iii) polls for lectures and labs, iv) general study material, v) online seminars, vi) interaction with students, and dynamics during classes, and vii) lecture recordings. Henceforth, in this section we analyze and discuss the results obtained from our 45 students.

A. *Presentation of the results*

In Tables I, and II, we provide an insight into the set of statements that students evaluated using a *Likert scale* [9]. Our scale includes five levels of answers, from *Strongly Affirmative* to *Strongly Negative*. The sets of statements are designed to directly tackle students' experience with our teaching practices in a comprehensive remote teaching module with all supplementing features (e.g., polls, recorded material, etc.). The feedback from students is collected in two iterations, with the same set of statements. In order to obtain an in-depth analysis of the results, which is not biased by insufficient experience with using the tools, the first iteration was performed in the middle of the semester, and the second one was performed at the end. Furthermore, in Figures 3, 4, 5, 6, and 7, we present the results that are calculated according to equation (1), which was applied to the collection of students' answers in order to prepare them for fair comparison and rigorous analysis. The equation (1) calculates the average number of votes for a particular category (from Strongly Affirmative, to Strongly Negative) expressed as a percentage, where M is the number of survey iterations ($M = 2$), N_j is the number of responses in j-th iteration ($0 \leq N_j \leq 45$), and a_{ij} is the student's answer for i-th category, in j-th survey iteration ($a_{ij} = \{0, 1\}$).

$$\frac{1}{M}\sum_{j=1}^{M}\frac{\sum_{i=1}^{N_j} a_{ij}}{N_j} \cdot 100\% \qquad (1)$$

B. *Discussion*

a) Lectures and laboratory sessions: With reference to Table I, which presents statements that tackle lectures and laboratory sessions, Figures 3, 4, and 5, clearly show a positive attitude towards the remote classroom. In particular, if we jointly consider statements S1, S2, and S5, that concern Lectures, and statements S1, S2, S5-S8, S10, and S11, tackling labs, we can see that majority of the students (S1: 66,667%, S2: 76,19%, S5: 28,572%, in case of lectures, and S1: 76,19%, S2: 76,19%, S5: 42,858%, S6: 76,19%, S7: 80,952%, S8: 61,904%, S10: 42,858%, S11: 61,905%, in case of labs) express satisfaction with collaboration with instructors, and the learning process throughout the online teaching. Applying a statistical *Student t-test*[3] on the collected sample of results, we obtained the $p_{value} = 3.602e-05 < 0.05$, which means that the difference between positive and negative attitude

[3]Student t-test: https://www.ruf.rice.edu/~bioslabs/tools/stats/ttest.html

towards new practices is also statistically significant. From an educator's perspective, this result is quite important since it justifies the idea and the efforts invested to approach teaching and work in laboratory in a remote, but an interactive way. However, students recognized that connectivity issues affected the teaching process, but not to a significant extent. The reported issues mostly tackled the inability to share the screen all the time, but such obstacles can be efficiently addressed by using the options to share the material on the course page, or to initiate a topic for discussion. Another potential issue that is recognized, and refers to the statement S4 for the labs, might be the physical absence of teaching assistants affecting the understanding of lab material. Around 28% of responses acknowledged an impact of teaching assistants' absence on the grasping the lab tasks. This potential issue can be further solved by encouraging students to read the lab material in advance, and to prepare the potential questions for discussion in the breakout groups.

b) Polls, Study material, Seminars, Interaction with students, Recordings: The statements presented in Table II are designed to directly tackle the tendency in favor of these supplementary teaching features. We applied the t-test on the results shown in Figures 6, and 7. The p_{value} for the polls is equal to $0.0019 < 0.5$, expressing the significant difference between positive and negative answers concerning the experience with polls. Although the students were aware that polls created dynamically during online classes were not anonymous, most of them (85,714%) feel comfortable to give an answer, and test their knowledge.

Despite the slight advance in favor of supporting the additional teaching features, the difference between positive and negative answers that tackle a study material, recorded seminars, and interaction with students via public announcements on the course page, is not statistically significant. However, the $p_{value} = 3.075e-05$ obtained for the recordings of lectures, and labs, classifies this feature as a highly appreciated addition to the traditional teaching. Such result is, of course, reasonable as recordings undoubtedly help students to refresh the study content that was previously uniquely presented during the online lessons. The results presented above show that our comprehensive remote teaching module, which is enabled by MOOCs, and used to deliver both lectures and hands-on laboratory exercises, brings opportunities to improve students' learning experience by:

- efficiently addressing the challenges imposed by imminent campus closures that restrict the access to traditional classroom resources,
- responding to a boosted enrollment of the students, thereby providing students with a massive large scale interaction during online lessons,
- providing homogeneous study material to all students,
- giving students the opportunity to watch recorded lectures/laboratory sessions, thereby bridging the gaps in knowledge caused by potential absence,
- providing both students and lecturers with the opportunity to identify gaps in students' knowledge by polling, and

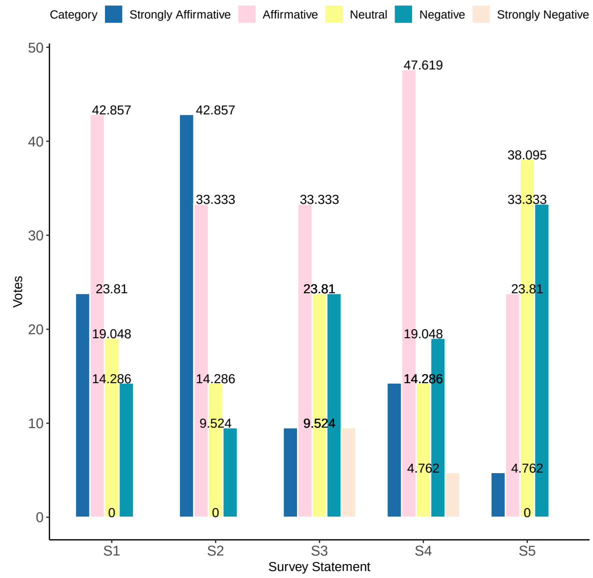

Fig. 3: Students' evaluation of Lectures.

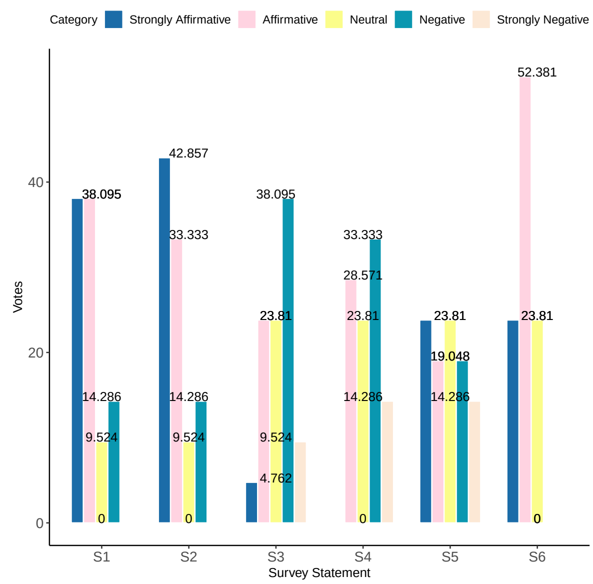

Fig. 4: Students' evaluation of Laboratory exercises - part 1.

- allowing lecturers to adjust the content of the lectures/laboratories *on-the-fly*, while analyzing students' feedback and responses in the polls.

V. Conclusion

In this paper, we presented our teaching practices on enabling a comprehensive module for remote teaching via Blackboard platform. With the inclusion of the Blackboard Collaborate Ultra extension, we have efficiently reacted to the challenges of campus closure imposed by COVID-19 breakout. We presented an extensive survey as a feedback from students, which enabled us to measure and quantify their experience and satisfaction with the remote teaching approach

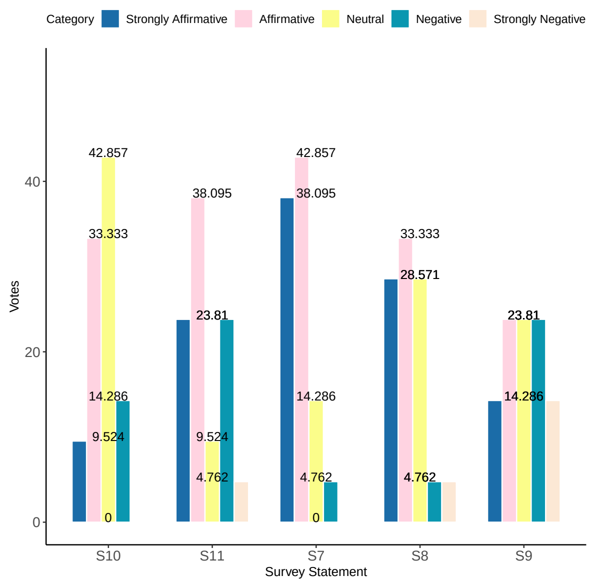

Fig. 5: Students' evaluation of Laboratory exercises - part 2.

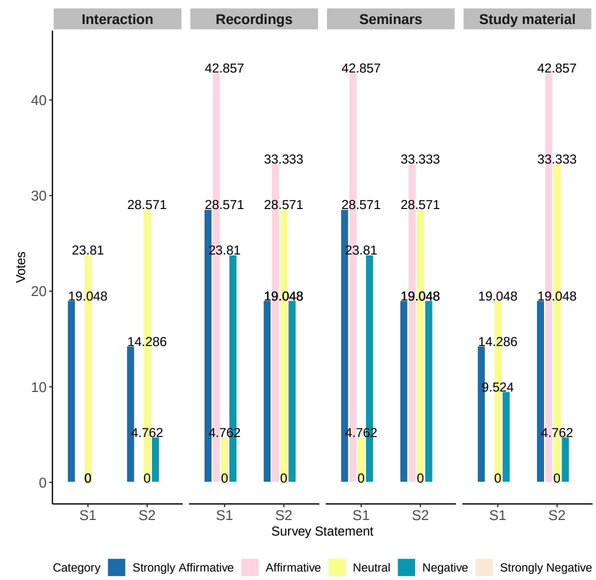

Fig. 7: Students' evaluation of additional BB features.

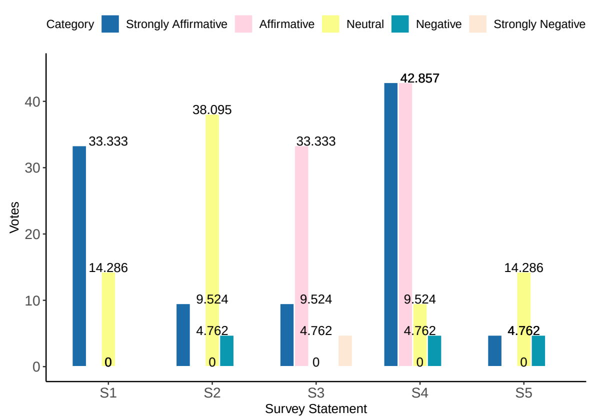

Fig. 6: Students' evaluation of Polls.

that successfully served 45 enrolled students. Our results reflect the positive attitude towards practices presented in this paper, and such teaching practices can serve as a meaningful example on how to efficiently cope with the limited access to traditional classroom resources for the different courses.

References

[1] S. N. Hamade, "Student perceptions of learning management systems in a university environment: Yahoo groups vs blackboard," in *2012 Ninth International Conference on Information Technology - New Generations*, pp. 594–599, 2012. http://dx.doi.org/10.1109/ITNG.2012.126.

[2] H. Yang, Z. Xing, Q. Wang, and Y. Han, "Experiences in blended learning based on blackboard in hubei university of education," in *2018 13th International Conference on Computer Science Education (ICCSE)*, pp. 1–6, 2018. http://dx.doi.org/10.1109/ICCSE.2018.8468750.

[3] N. Slamnik-Krijestorac, H. C. Carvalho de Resende, and J. M. Marquez-Barja, "Practical teaching of distributed systems: A scalable environment for on-demand remote experimentation," in *Submitted to EAI GOODTECHS 2020 – 6th EAI International Conference on Smart Objects and Technologies for Social Good*, 2020.

[4] D. Pishva, G. G. D. Nishantha, and H. A. Dang, "A survey on how blackboard is assisting educational institutions around the world and the future trends," in *2010 The 12th International Conference on Advanced Communication Technology (ICACT)*, vol. 2, pp. 1539–1543, 2010. Online: https://ieeexplore.ieee.org/document/5440323.

[5] C. Hicks, "The use of managed learning environments and automated assessment for supporting large-group teaching," *Engineering Science and Education Journal*, vol. 11, no. 5, pp. 193–198, 2002. http://dx.doi.org/10.1049/esej:20020504.

[6] L. Zheng, "Application of blackboard system in the course of computer programming," in *2010 5th International Conference on Computer Science Education*, pp. 648–651, 2010. http://dx.doi.org/10.1109/ICCSE.2010.5593528.

[7] K. Al-Omar, "Evaluating the usability and learnability of the "blackboard" lms using sus and data mining," in *2018 Second International Conference on Computing Methodologies and Communication (ICCMC)*, pp. 386–390, 2018. http://dx.doi.org/10.1109/ICCMC.2018.8488038.

[8] N. Slamnik-Krijestorac, S. Bosmans, P. Hellinckx, and J. M. Marquez-Barja, "Enhancing students' learning experience via low-cost network laboratories," *IEEE Communications Magazine*, vol. 57, no. 11, pp. 34–40, 2019. doi: http://dx.doi.org/10.1109/MCOM.001.1900233.

[9] R. Likert, *A Technique for the Measurement of Attitudes*. 1932. Online [Available]: https://books.google.ie/books?id=9rotAAAAYAAJ.