The Challenges and Benefits of Regular Face-to-Face Interactions at Large-Scale Blended Learning Courses

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Abstract: One of the challenges of large-scale blended-learning courses is to provide individual feedback to the students. This paper describes an approach where a large-scale online course is combined with regular face-to-face interactions to improve the quality of individual feedback. The aim is to provide each student in large cohorts with personalized high-quality feedback to improve their learning success. In this paper, three aspects are highlighted namely, the challenges of feedback at large cohorts, the benefits, and how we have successfully organized this in our large-scale course.

Introduction

With the rise of large-scale online learning courses, the interaction between lecturers and students changed fundamentally. Before, students were able to interact face-to-face with each other or with teachers or teaching assistants (TAs), and to get direct and personal feedback. However, in large-scale blended courses, this is not possible anymore and the focus of students' interaction changed to digital collaboration via message boards or other means. This reduction of face-to-face interaction and feedback might be a reason for an increased drop-out activity in many large-scale online learning courses, compared to traditional lectures (Clow, 2013). It is well known that feedback plays an important part in students' learning outcomes (Hattie & Timperley, 2007). However, the way and how the feedback is provided plays an important role as well (Sadler, 2010).

Feedback consists of several important aspects. It can have different facets such as providing both corrective information and alternative solutions, helping to clarify ideas, evaluating the correctness of a response, or providing an estimation of the current knowledge level. Important for valuable feedback is that it should provide learners with information about how they can close the gap between their current and the expected knowledge (Sadler, 1989). It is well accepted that feedback can make a difference to learning in higher education. However, the way and type of feedback are important for its success (Butler, 1987; Crisp, 2007). Feedback is required to take into account the current knowledge level of the student and to provide help based upon that level with the goal to reach the required level (Sadler, 2010).

This requires that, before adequate feedback can be provided, the current knowledge level of the students' needs to be assessed. There are various approaches to implement automatic or semi-automatic feedback for large-scale courses (Shatnawi, Gaber, & Cocea, 2014) or approaches making use of peer feedback (Hanrahan & Isaacs, 2011; Li & Liu, 2011). However, all approaches lack some important parts a feedback should contain. With automatic or semi-automatic feedback, the correct estimation of the current knowledge is very hard to reach, as only a final solution can be evaluated, and the process of the generation of the solution can only be partially represented. Therefore, most online learning courses take an approach where an automatic or semi-automatic feedback to the students is provided based on their handed in solutions. With peer feedback, the problem is that the knowledge of the peers is very similar to the students' knowledge, such that they struggle to provide corrective information or assess the correctness of the produced solution.

In this study, we present an alternative approach where face-to-face discussions are used on a large-scale blended-learning course to provide feedback which is able to fulfill the requirements for a good feedback as stated above. As the knowledge of the students might only be partially represented in their solutions, which makes it hard to use the solution for an estimation of their knowledge. But as stated above a good estimation if knowledge is required for a good feedback. Therefore, with individual discussions, a better estimation of their individual knowledge could be achieved.

In this study, findings from a case study of a large-scale blended-learning course with 790 first-year students in an introductory computer science course for natural scientists is presented. The aim was to provide every student of this large cohort with regular individual feedback. To achieve this, an approach was developed where distance learning is combined with intermittent face-to-face discussions. During presence phases, a Teaching Assistant (TA) discusses with a student her or his individual solution of a given task and provides the students with feedback based on the students' knowledge level. The aim is that every student gets regular feedback and feed-forward on their learning progress, helping them to focus on the core concepts of the course and to stay active through the whole course (in total around 120h of workload).

This paper consists of three parts. First, the background and challenges are described, which then lead to the development of our system of individual coaching and feedback for students. The second part describes and evaluates the benefits of the suggested approach. In the third part, the system, developed to organize this at large-scale, is presented and evaluated.

Part 1: The Challenges of Large-Scale Introductory Courses

In this section, the main challenges are presented, which lead to the developed system of individual coaching and feedback for large cohorts. Different challenges are highlighted and our responses to these challenges are described.

Large Cohorts

For this paper, the data from an introductory course to computer science for natural and applied sciences was used. This is a blended-learning course for first-year students from biology, pharmacy, health science, environmental science, earth science, food science, and agricultural science. The course introduces the students to the foundation of scientific data processing and programming. There were 820 students registered for the course. 790 students actually participated at least once in the course. From these 790 students, 62% were female, and 22% were repeaters, meaning that they need to repeat the first-year exams. To pass the course, the students needed to pass an exam at the end of the semester. 683 students took this final exam and 14% failed.

Heterogeneity and lacking prior knowledge

A common factor of the students is that only 13% percent of them had any computer science education at high school and therefore had a prior knowledge about computer science. Another challenge is the diverse background of the students and their different areas of study. To cope with this diversity, the students got access to self-learning units (including online tutorials, videos, quizzes, etc.) in order to prepare themselves to solve demanding project tasks with a scientific context, independent of their prior knowledge.

Duration and Workload

Another challenge for the course is to ensure that the long duration and the total workload of distance learning for the students do not lead to an increased drop-out rate. The duration of the whole course is 13 weeks, which is split in six windows of two to three weeks, in which different topics are covered. In each time window, the students have to work through online learning materials, which takes around 10-20h, depending on the students' prior knowledge. The online learning system is developed based on the work of Faessler et al. (Faessler et al., 2006). The online learning materials consist of a tutoring system which guides the students through the new topic. The aim of this tutoring system is to reduce the inequality of knowledge due to the diverse backgrounds and prior knowledge. After using the tutoring system, the students are presented a demanding problem-based project, which they need to solve. The project is designed in a way such that the solution is open, to allow that the projects adapt to the knowledge level of the students. After each of these projects, there is a face-to-face interaction, where the students need to present their projects to a TA. This takes around 10-15min. This results in the students working more than 95% in distance learning and less than 5% in presence learning. In total, our students are expected to have a total workload of around 100-120h, where

around 6h are presence learning. In this paper, the focus is on the importance of the 5% face-to-face interaction phase, and the benefits this provides compared to other forms of assessing the learning progress of the students.

Deep Learning

An important goal for higher education is to achieve deep learning. A crucial prerequisite for deep learning was identified as the personal interaction between the teacher and the students (Offir, Lev, & Bezalel, 2008) and to focus on understanding (Biggs & Tang, 2011). This requires teachers to provide individual coaching and feedback to their students. At large scale this becomes infeasible, due to the workload. Therefore, we developed a system that admits individual coaching with the help of TAs.

Data Collection

To evaluate the course, different measurements were taken. The participants took part in both a post-course survey and a process analysis. The post-course survey was completed by 502 students. In addition, they took part in a process analyses (see Figure 1), where the same questions were asked after each window. If not stated otherwise, all questions were asked on a Likert scale encoded from 1 for strongly disagree to 5 for strongly agree. This allows us to monitor changes in students' motivation or other important factors during the whole semester. In addition, different parameters were collected from students' usage of the online learning materials and during the face-to-face interactions.

Part 2: Benefits of Face-to-Face Interactions

As stated above, an important factor for students' success is that they learn to estimate their current knowledge, and for this feedback and feed-forward are one of the most important factors (Hattie & Timperley, 2007; Sadler, 2010). Feedback is only successful if it is targeted at specific individuals. To achieve this in our course, individual face-to-face discussions between students and TAs were developed, which helps the students to estimate their current level of knowledge and to detect topics where they have not yet reached the required level. The important aspect was to focus on the students' level of understanding and not on their solution. To estimate the current learning progress, every student took part in a direct face-to-face discussion with a TA. During the discussion, the students need to present and explain the project to the TAs. The TAs guide the students through the discussion and help them to focus on the important scientific aspects. At the end of the discussions, the TAs provide the students feedback and feed-forward. This allows to give a specific feedback targeted at individual students, based on their current knowledge level. These discussions are rated internally by both the TAs and the students with the following grades: 0, 1, or 2. If the student has no understanding of the current topic, the TAs should give him or her a 0. Students with an average understanding of the current topic are marked with 1, and students which gained a fundamental understanding of the topic are marked with 2. The mark aims to be a representation of the knowledge level of the students on the topic and not of the actual solution of the given task. This mark does not have any influence on the final grade. Neither does it have any negative consequences for the students. The TAs are asked not to tell the students their mark, but instead provide them with high-quality feedback and feed-forward. In the next sections, we will show some benefits the students obtained by this system.

High Success Rate

The regular feedback increases the chances to successfully finish the course, as the learners know their level of knowledge, which helps them to focus on their individual knowledge gaps. In addition, the TAs provide feed-forward helping the students to focus on the important aspects of the facts they are expected to know at the exam. This helps to align the exam to the course materials and therefore increases the success rate (Biggs & Tang, 2011). These assumptions could be supported by the outcomes of the exam compared to other courses our students are taking. The success rate of 86% in our course is, compared to other courses at our university (average success rate < 65%), very high. In addition, the average mark is much higher than in other courses. The main factors for these findings are believed to be due to the good aligning process.

No Plagiarism

As the discussion is not focused on the produced solution but on students' understanding, the TAs have less trouble with plagiarism. Students are encouraged to work in teams on the projects, so that there are similar solutions. However, as the TAs are focused on the individual knowledge the students have gained by working through the project plagiarism is not a concern. In addition, students refrain from discussing solutions where they did not participate at all in a face-to-face interaction, as they fear the awkward situation if the TA detects it.

Increased Fairness

There will always be differences in the competence of the TAs which cannot be removed by supervision and training, such that, in traditional exercise sessions with fixed groups, students might be handicapped compared to other groups. This problem of unfairness can be circumvented by randomly matching TAs to students repeatedly. In the presented system, each student is randomly assigned to a TA for each module, such that only 10% of the students has the same TA more than once.

Focus on a Single Student

With the individual discussions, it is possible that, even at a large-scale of 790 students, each student gets an individual time period every two to three weeks, where individual feedback is provided by a TA. Especially for first year students in a subsidiary subject, this is important to cope with their low motivation and low prior knowledge. From observations it is clear that their confidence to talk to the TAs is increasing over the semester. Another benefit of having individual time slots with each student is that no student can slip through our net and get lost. This is supported by the low fail rate in our course compared to other courses at our university. Another indicator is the decrease in the students' expectation to get a good or very good grade at the final exam. As one can see in the process analysis (see Figure 1) the question where they need to estimate their final grade drops from unrealistic 75% to around 50%, which is more realistic. The overestimation is due to that most students at our university have been among the best students in their high-school classes, such that they have at the beginning a too optimistic self estimation. The regular feedback helps them to gain a more realistic estimation of their current knowledge.

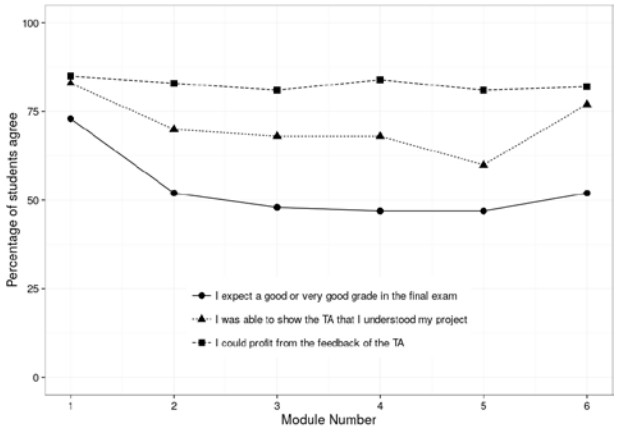

Figure 1: Progress analyses, where the students are asked the same questions six times over the semester. The percentage of agreement to the questions is displayed (N = 541).

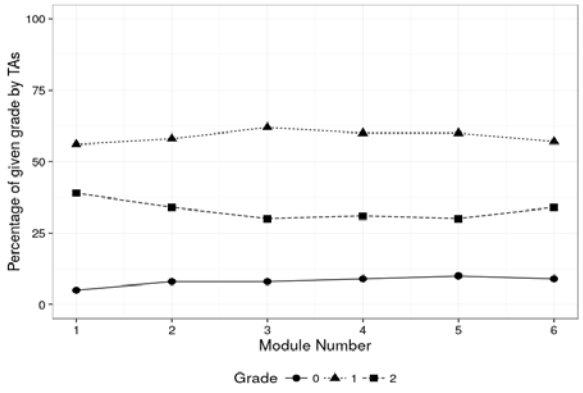

Figure 2: The grades the students received from the feedback discussions over all modules (N = 635).

The Students Stay Active During the Semester

The regular feedback should increase the activity of the students in the course, as it helps to keep the learners engaged (Park & Choi, 2009). As the grade the students receive for their individual discussion does not have an influence on

the final mark, the students could actually stop preparing their projects and then would receive 0 points by the TAs. This would then result in an increase of the mark 0 during the semester. However, this effect was not observed in our group of students (see Figure 2). Only after the first module, the percentage of 0 points increased from 5% to 8%. This could be interpreted as some students giving up at the beginning of the semester. After the first loss of students, there is only a small increase from 8% to 10%. Overall, more than 90% of our students stayed active during the whole semester, which is a very high activity compared to other blended-learning courses (Clow, 2013).

The Measurement of the Learning Progress Correlates with the Final Mark

It is important to make sure that the measurement of the students' learning progress is actually valid, e.g., reflects the reality. Therefore, the estimations of the learning progress by the TAs were correlated with the performance of the students at the final exam. If one assumes that the measurement does actually represent the learning progress of the students, this should correlate with the exam performance. The higher the estimation of the learning progress of the students by the TAs, the better the exam performance should be. If a linear correlation between the P-value of the marks given by the TAs and the percentage rank reached in the exam is calculated, a significant P ($P < 2.2\ 10^{-16}$) and positive correlation ($R^2=0.24$) is seen (see Figure 3). It is important to note that these results are based on individual estimations of our TAs, over a long period of time. Nevertheless, the marks of the TAs seem to be one of the best prediction factors for the final exam we have seen so far. To gain this significant correlation, it is important that the TAs know their job, and that their grading is done in a reliable way.

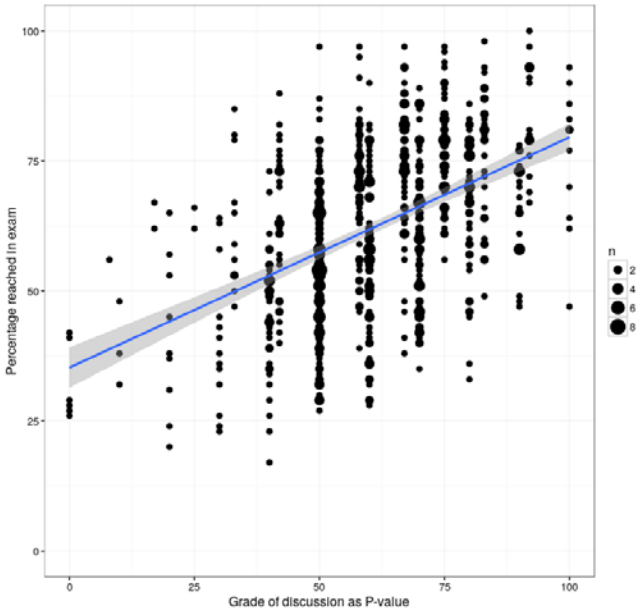

Figure 3: Regression between the P-value of the marks given by the TAs and the percentage rank in the final exam. The blue line represents the regression curve through the data and the gray shadow represents their 95% confidence interval.

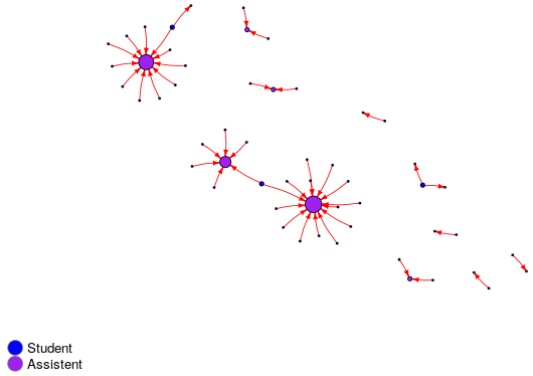

Figure 4: Analytic dashboard for lecturers to identify problematic TAs. It consists of a graph where the students which graded their TA with 0 are displayed as vertices directed towards the TA. One can now easily identify TAs who got bad grades from different students, as they have several red vertices directed towards them, which is an indicator for problems. In this example one can easily identify three TAs which show problematic patterns. This helps lecturers to focus their supervision on them.

Ensuring the Competence of the TAs

As noted above, it is very important to ensure that the TAs are able to reliably estimate the knowledge level of the students and give the students adequate feedback. The work of the TAs is fundamental for the success of the face-to-face discussions, and therefore the lecturer must rely on that they are able to do their work with the highest quality

possible. This requires that the TAs are trained for their job and that they are supervised and monitored to improve their skills over time. Due to the large amount of TAs, the lecturer is not able to supervise each TA on a regular basis. To enable TAs to provide good feedback and feed-forward to the students, they are trained in several steps. Before the semester starts, they get an introduction on how to ask questions and how to lead the discussions in a way that enables the TAs to estimate students' learning progress. During the semester, there are two meetings where they reflect on the discussions they had so far. In addition, the lecturer visits every TA at least once and listens to a discussion and then provides feedback to the TA. To detect problems the students are asked to evaluate each discussion. They mark the quality of the feedback of the TA and the discussion. This marking of the TAs can be monitored by the lecturers via a learning analytic interface, such that the lecturer is able to identify the TAs who need additional supervision and training. One interesting feature is that, if a TA gets several bad grades from different students, this TA is displayed in the lecturer's dashboard and can therefore be identified easily (see Figure 4). Overall, our students were very satisfied with the TAs over the whole semester. The TAs got an average grade of more than 1.60 without much fluctuations over the semester (see Figure 5). Other indicators are the two questions in the progress analyses, where the students are asked whether they profit from the feedback of the TA and whether they could show that they understand their project to the TA (see Figure 1). The first questions focus on the quality of the feedback provided by the TA. There the students are very satisfied with our TAs (more than 80% agreement of the whole semester). The second question asks whether the TA focused on the student. There the agreement drops down to 60%, which is not the quality we want to reach. Therefore, during the introduction of the TAs, the focus should be more on the way how to guide the discussion and how to ask the questions.

Evaluation of the Face-to-Face Discussions

For the evaluation of the system, some questions were asked during the post-course survey. The students were asked to rate the usefulness of the different support and learning materials they were provided with. The presentation of the modules got on average 4.41, which is very high, compared to other parts in the course such as videos (1.24) or lecture slides (1.49). Also other questions targeted at the face-to-face discussions, like how it helped to distribute the workload (4.25) or how it helped to estimate their knowledge level (3.75) were clearly positively answered by the students (see Table 1). Most of the students agree that the system should be implemented in other lectures (3.7).

Especially the rating of the usefulness compared to other concepts which are often provided in distance learning courses was surprising and it showed that the students really want to have face-to-face interactions where they get individual feedback based on their current learning process. On the other hand, the system also helped them to better distribute the workload over the semester and helped them to better self-estimate their current knowledge level. This finding is supported by the process analysis, where more than 80% of the students agreed or strongly agreed that they profit from the feedback discussions during the whole semester (see Figure 1).

Efficiency for Large Classes

It seems that the individual discussions are very labor-intensive and require a lot of micromanagement, compared to other means of learning control measurements. Compared to traditional exercises where the TAs need to correct the hand in solutions, the system of individual discussion takes around the same amount of time of around 10-15min per student per exercise/project. However, the students profit more from the discussions, as they get an individual feedback based on what they know and not what they have produced. Compared to automatically corrected exercises, the system of the presentation is much more time-consuming, but the feedback provided to the students is more personal and based on their current knowledge. In addition, automatically corrected exercises or projects make it difficult to use learning materials with no closed solution. Another advantage is that the required infrastructure can be utilized better. With the developed system, it is possible that several TAs work in the same room without interfering. However, the micromanagement of assigning the rooms and TAs to students in large cohorts can only be managed with automatic systems.

The regular presentations with a TA helped me to distribute the workload over the semester				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1%	3%	15%	47%	34%
The regular presentations with a TA helped me to better estimate my current knowledge level on this topic				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1%	10%	32%	44%	13%
I would like to see the introduction of individual coaching and feedback in other subjects				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4%	14%	32%	32%	18%

Table 1: Responses from post-course survey on the face-to-face presentations (N = 502).

Part 3: Our System to Organize Face-to-Face Interactions

As mentioned above, to organize these individual discussions is very time-consuming, in our case we had to organize 850 discussions every two weeks which takes around 10-15min, resulting in around 5000 discussions. This workload cannot be handled by the lecturer alone, and a large amount of TAs (in our case around 45) is required. But even then the micromanagement of organizing the discussions cannot be handled without an automatic tool. Therefore, PELE (personal electronic learning environment), a tool to organize individual student coaching and feedback, was developed. The benefits of the face-to-face interactions are very obvious. However, the successful implementation of the face-to-face feedback discussions at large-scale is another story. To implement these feedback discussions at large-scale and to take care of the micromanagement, PELE was developed. The system differentiates three roles: students, TAs, and lecturers. The most important details of the three roles are provided in the next sub sections.

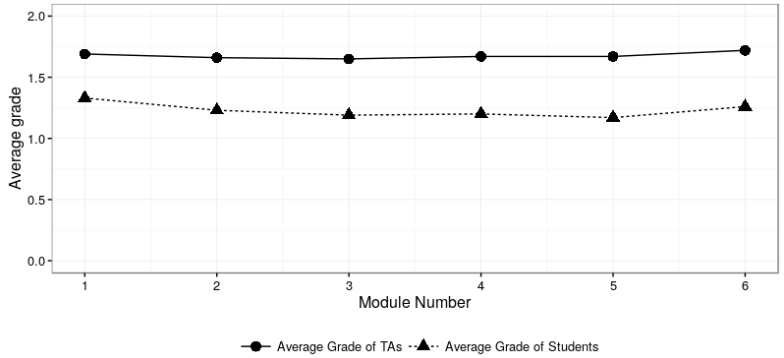

Figure 5: The average grade of the students and TAs over the whole semester. Important is that the fluctuation is relatively low over all modules (N = 635).

Student View

Students can sign up for a presentation slot via PELE by selecting an available slot, as soon as they are ready for the presentation . During the sign-up, they see some indicators of how many other students are already signed up and how

many slots are left. This helps the system to gain a better distribution of the students over the available time slots, improving the workload of the TAs. After the signup, the students are assigned to a room, where they need to show up for their face-to-face presentation. The students are not given an exact time but a window of one hour in which their presentation is going to take place. They will then go to the room they are assigned to and wait until a TA calls their name and then conducts the face-to-face feedback discussion. After the discussion, the TA grades the students, then the students are asked by the system to give their feedback, and after this, the project presentation of a two to three week window is fulfilled. If a student does not show up, an email is sent by the system with a link to a webpage where the student can give a reason for not showing up. A student will then get an additional possibility to present the project. The main focus of the student view is to have a easy-to-use system. Therefore, PELE is web-based and mobile ready, and a lot of care was taken to guide the students through the whole process.

TA View

The TAs also use PELE to organize their work (see Figure 6). They sign up at the beginning of the semester for the rooms they will take care of during the semester. If they are absent at a certain date, the system makes it easy for other TAs to help out and take over a slot. The TAs will then show up in their assigned room. Normally, four to five TAs share one room. PELE provides them a real time table of the signed-up students ordered by the time of sign-up. They will then select the first student in the list and call his or her name. This student is then removed from the list, such that we do not get a situation where several TAs call the same student. If a student is not present during the call of a TA, the student's name is moved to the end of the list. After the face-to-face discussion, the TA grades the student and then calls the next student on the list. The focus of the TA view is that the system is easy to use and allows them to call and grade the students with a mobile device, directly in the classroom.

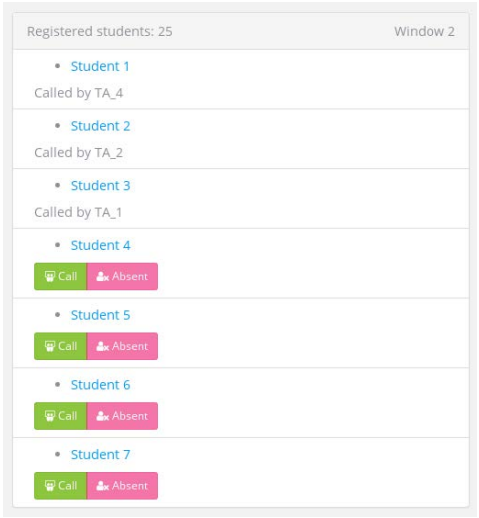

Figure 6: A single room during the presentation slots. The students are shown together with their current status. Therefore, the TAs see which students were already called by the other TAs, and which student to take next. All data is live and synced between all TAs.

Figure 7: Lecturer view to oversee the current status of the different rooms of the lecture, with each four to six TAs. Slots where not enough TAs are present are marked in red. The filling of the small star displays the amount of students signed up for the slot. In this example, the slot on Monday at 9 o'clock is full.

Lecturer View

The third view is provided to the lecturers. They need to have an overview of the current status of the lecture. To get an easy overview, they are provided with several indicators about the different rooms, for example, they see, how many students signed up and how many TAs are currently in the room (see Figure 7). If there are too many students signed up for the available TAs, they are informed. This might happen if TAs are ill or not available. The lecturer can

then react and for example move TAs from a different room or organize additional TAs. This is very important to have an overview about the 45 TAs and the large cohort of students. Additionally, lecturers have access to a learning analytic dashboard, where they can see different indicators about the learning progress of the students and the face-to-face discussions. For example, they can see the feedback the students give to the TAs or the marks the TAs give the students. This allows the lecturers to react if there are any abnormalities, e.g., when a TA is only giving 2 points to the students, or a TA gets very bad grades from the students. Particularly these analytic parts of the lecturer view help to keep the quality of the face-to-face discussions on a high level. Without these analytics, they would not know what to focus on and where to intervene.

Evaluation

To evaluate the technical platform, the students were asked in the post-course survey how difficult the usage of the system was (4.65), and how fair they find the process (4.59). It seems that the students had no problems with the usage of PELE and that they accept the distribution of the slots by the first come first serve principle. The TAs also took part in a post-survey, which was completed by 42 of 45 TAs. They also saw no problems with the usage of PELE (4.76). In addition, they were asked to evaluate how the system changed their way of teaching. This was done via qualitative questions. The main responses can be classified into three categories. One point was that PELE helped to reduce the organizational overhead by taking care of the micromanagement. Additionally, it helped to make sure that no students slipped through the net, and that every student gets roughly the same amount of time. Answers from the last category stated that their role changed in that, instead of an instructor, their role was more that of a coach or guide on the side which gives the students tips on what they should focus on and where they should be heading next. However, it is also clear from these answers that not all TAs were satisfied with their new role. Some (2 out of 42) still prefer a more traditional approach of teaching, where they present to the students in a lecture style in front of the class.

Conclusion

The benefits of the individual face-to-face interactions are important for large-scale blended-learning courses to help students to participate successfully and motivated. The main challenge for a widespread implementation is the enormous personal and financial cost of this approach, compared to automatic tools. We are in the convenient situation that we can afford this huge amount of resources to a lecture, which we know is very unusual for a lot of tertiary institutions and online courses. However, the benefits should show that the resources are put to a good use.

Traditional exercise classes might also benefit from individualized face-to-face discussions. It would help to provide more individual feedback compared to correcting solutions and discussing them without a larger workload. However, the described set-up provides some additional benefits like increased fairness, monitoring of TAs, greater flexibility for students, and better targeted education of the TAs. This is possible due to the collection of important data during the whole process. One could also argue that traditional exercises face a problem with larger cohorts, as then the monitoring and supervision of TAs becomes a challenge. The described setup allows lecturers to constantly monitor the performance of the TAs and it allows them to take data-driven actions.

Another obstacle for the successful implementation is that at large scale this approach heavily depends on the work of the TAs. This requires the TAs to accept this system, which means for some of them that they need to change their more traditional views on teaching and think of themselves as learning partners and coaches. It is also fundamental that the quality of individual discussions and coaching is as good as possible. This requires that lecturers monitor and supervise their TAs, especially in the beginning. The training of the TAs also plays an important role and helps, in our experience, to improve the quality significantly. However, this requires that the lecturers also change their role by focusing more on the TAs than on direct interactions with the students. From our experience this system requires a fundamental change in most parts of a lecture, e.g., one needs to adapt the learning materials (open questions), get rid of traditional exercises, and focus on students' understanding and not simply on the produced solutions anymore. This is very challenging and fundamental, however, the individual coaching and feedback might be critical for students' learning and success, and it should also be tried to implement it at other large-scale classes. The reason that most large-scale courses reduce the face-to-face interactions is due to the difficult handling and

workload. We think that with our approach this will also be possible at even larger scale. The limiting factor for this approach is the number of TAs that can be trained and supervised. However, this task can also be distributed among different shoulders such that not one lecturer alone needs to handle all the workload concerning the TAs.

References

Biggs, J., & Tang, C. (2011). *Teaching for Quality Learning at University (Society for Research Into Higher Education)*. Open University Press. Retrieved from http://www.amazon.com/Teaching-Learning-University-Research-Education/dp/0335242758

Butler, R. (1987). Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest, and performance. *Journal of Educational Psychology*, *79*(4), 474.

Clow, D. (2013). MOOCs and the funnel of participation. *Proceedings of the Third International Conference on Learning Analytics and Knowledge - LAK'13*, 185. https://doi.org/10.1145/2460296.2460332

Crisp, B. R. (2007). Is it worth the effort? How feedback influences students' subsequent submission of assessable work. *Assessment & Evaluation in Higher Education ISSN:*, *32*(5), 571–581. https://doi.org/10.1080/02602930601116912

Faessler, L., Hinterberger, H., Dahinden, M., & Wyss, M. (2006). Evaluating student motivation in constructivistic, problem-based introductory computer science courses, (Snyder 1999), 1178–1185.

Hanrahan, S. J., & Isaacs, G. (2011). Assessing Self- and Peer-assessment: The students' views. *Higher Education Resarch & Development*, *20*(1), 53–70. https://doi.org/10.1080/07294360123776

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112. https://doi.org/10.3102/003465430298487

Li, X., & Liu, H. (2011). Student participation and teaching innovation: The perspective of knowledge transfer in the process of teaching. In *2011 International Conference on E-Business and E-Government, ICEE2011 - Proceedings* (pp. 9038–9041).

Offir, B., Lev, Y., & Bezalel, R. (2008). Surface and deep learning processes in distance education: Synchronous versus asynchronous systems. *Computers & Education*, *51*, 1172–1183. https://doi.org/10.1016/j.compedu.2007.10.009

Park, J. H., & Choi, H. J. (2009). Factors influencing adult learners' decision to drop out or persist in online learning. *Educational Technology and Society*, *12*(4), 207–217.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, *18*, 119–144.

Sadler, D. R. (2010). Beyond feedback: developing student capability in complex appraisal. *Assessment & Evaluation in Higher Education*, *35*(5), 535–550. https://doi.org/10.1080/02602930903541015

Shatnawi, S., Gaber, M. M., & Cocea, M. (2014). Automatic Content Related Feedback for MOOCs Based on Course Domain Ontology. Lecture Notes in Computer Science, 8669, 27–35.

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