The effect of introducing on-line quizzes in a virtual learning environment and implications for the flipped classroom

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INTRODUCTION

This paper reports on an *action research* project [1] to improve teaching and learning in an elective master's course on nuclear reactor modelling at Chalmers University of Technology. The course is taught by the first author, and was originally delivered in a traditional campus-based format, with in-class lectures and tutorials. The assessment consisted of a number of home assignments, for which the students got help during the tutorials, attendance on at least 75% of the lectures, and a final oral exam.

The first cycle of the action research project was carried out during the academic year 2012/2013 [2]. During 2012/2013 the course was converted from a traditional campus-based course to a course delivered in a purely *virtual learning environment*, with pre-recorded lectures available for on-demand viewing – hereafter referred to as *webcasts* – and tutorials live-broadcasted with synchronous interactions between the students and the teachers. The teachers were available to answer questions during special sessions, to which the students had to register in advance. Although such a possibility was offered, not a single student registered to the synchronous sessions. The interaction between the teachers and the students only occurred during the tutorials, with the students more eager to complete the home assignments than to understand the underlying concepts.

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Drawing on the idea of *just-in-time teaching* (JiTT) [3], the course was then reformed again during the academic year 2013/2014. The main objective of this second cycle of the action research project was to increase the interaction between the teachers and the students for the course activities not related to the home assignments. This paper reports on the second cycle of the action research project, investigating the effects of introducing on-line quizzes on students' questions and webcast viewing. A quantitative research approach was employed with *learning analytics* as the main mode of investigation. Data was collected via a learning management system (LMS) for the 2012/2013 and the 2013/2014 versions of the course.

1 COURSE REFORM IN 2013/2014

In the 2013/2014 course reform, the following elements were added: on-line quizzes embedded in the webcasts, focusing on *conceptual understanding* [4]; the possibility to pose questions to the teachers while watching the lectures; easy and rapid rating of the lectures and the possibility for students to provide more specific feedback on the lectures; regular synchronous wrap-up sessions designed to address the students' needs and based on the input from the students; and discussion fora. Since the discussion fora were exclusively related to the home assignments, they are not discussed further in this paper.

The *on-line quizzes* were designed in such a way that thinking skills beyond merely remembering concepts were triggered, including applying, analysing and evaluating concepts [5]. The quizzes were carefully designed so that they required the students to comprehend the key concepts. Such active learning elements encourage a *deep approach to learning* [6]. Moreover, embedding quizzes in the pre-recorded webcasts allowed splitting the lectures (webcasts) into smaller chunks, increasing the students' attention and thus improving the conditions for learning. As an additional benefit, the on-line quizzes allowed the teachers to continuously monitor students' understanding of key concepts. The students could take the on-line quizzes an unlimited amount of times. The only feedback they were provided with when answering the quizzes was whether they gave the right answers or not.

The pre-recorded *webcasts* were complemented with the possibility for the students to easily pose questions to the teachers, using a built-in function in the player for the webcasts. By simplifying the process of taking contact with the teachers directly from the player, and without interrupting the flow of the lectures, the students more often posed questions. The students were also asked to time stamp the question, so that the teachers could more easily go back to the specific part of the recording. Systematic questions from various students at a given time during a recording might indicate difficulties, and thus leading to an opportunity to improve the lecture. At the end of each pre-recorded webcast, the students could also rate, on a voluntary basis, the pre-recorded lecture. By making the rating of the pre-recorded lectures easy and fast, again using a built-in function in the player, most of the students did rate the lectures. The students also had the possibility to provide written comments.

Based on the answers to the quizzes, the questions sent to the teachers, the rating of the pre-recorded webcasts, as well as additional comments provided by the students, the teachers could prepare *wrap-up sessions* designed to meet the students' needs. These wrap-up sessions contained three key parts: 1) providing a brief summary of the key concepts and their relation to the structure of the chapter so that the students could relate the details to the overall picture, thus favouring a more *holistic approach to learning* [7]; 2) answering the questions that the teachers received; and 3) going through the quizzes in an interactive way, and discussing different alternatives. This last part of the wrap-up sessions is where the degree of interaction between the

students and teachers was highest, and provided a last opportunity for the teachers to address misconceptions and direct the students onto the right track.

2 WEBCASTS AND ON-LINE QUIZZES

The analysis of the two versions of the course (2012/2013 and 2013/2014) is based on 29 pre-recorded webcasts. The shortest webcast was 14 min and the longest was 120 min. In the 2013/2014 version of the course, on-line quizzes were added to the webcasts, so the webcasts were split into chunks of maximum 30 min. Statistics on webcast attendance was gathered for both versions of the course. It should be pointed out that problems with the server resulted in the loss of data for webcast #18 in the 2012/2013 version of the course.

As is typical for courses offered in a virtual learning environment, the number of students following the course tends to drop significantly during the early phase of the course. This is clearly illustrated in Fig. 1, where the number of individual webcast users is shown for each webcast.

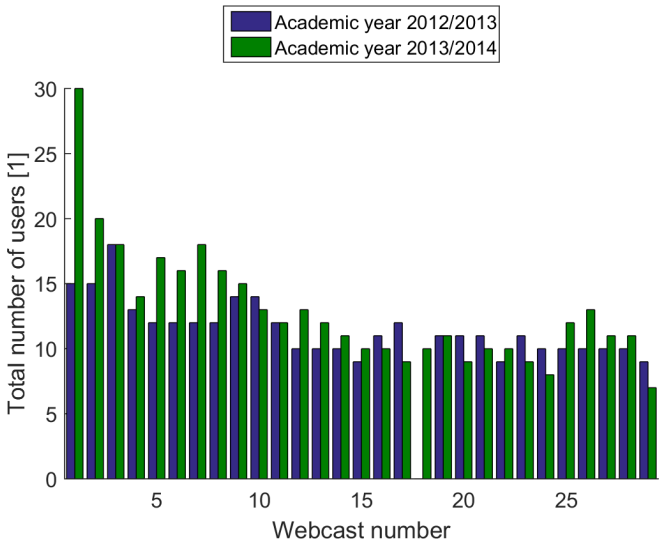

Fig. 1. Number of users across webcasts.

For both versions of the course, the course was offered in two set-ups. The students could either decide to engage with the following course activities to get the credit points for the course: attendance at 75% of the webcasts, solving a certain number of home assignments, writing a short summary after completing each chapter, and peer-reviewing these summaries. Or, they could decide to only attend the webcasts without getting credit points. The students in the first category will be referred to as *active* users/students, and those in the second category as *inactive* users/students. The students who decided to work to get the credit points but gave up during the course are also categorized as inactive. There were 7 active students in 2012/2013, and 5 active students in 2013/2014.

The number of respondents to the on-line quizzes as well as the success rate across webcasts is presented in Fig. 2. (Note that this kind of data is only available for the 2013/2014 version of the course, when the on-line quizzes had been implemented.) It can be observed that the number of respondents to the on-line quizzes is closely

following the number of individual users according to Fig. 1. This shows that most users of the webcasts did actually answer the on-line quizzes, including the inactive users. The success rate for the on-line quizzes is also relatively high. This, in itself, demonstrates that all students following the webcasts (both active and inactive) practiced multiple times to get the correct answer to the quizzes. For the active students, a separate analysis of their answers (not reported here) also revealed that their success rate was 100% and that they took the on-line quizzes on the average 1.8 times before getting the correct answer[2].

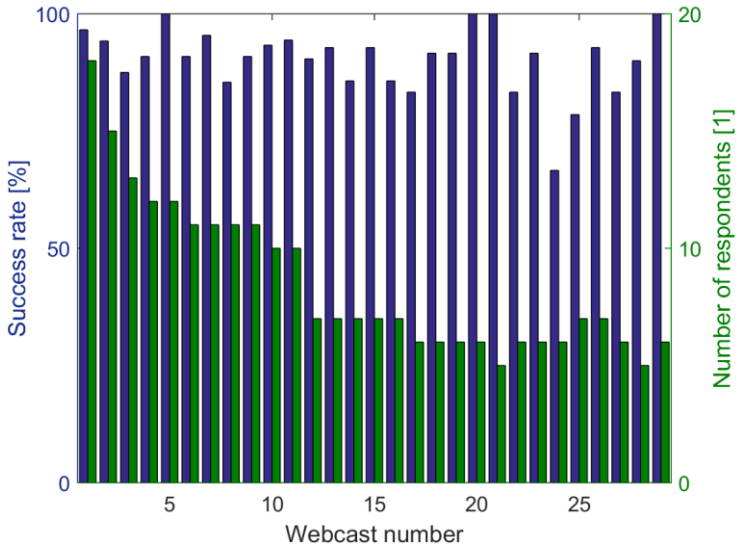

Fig. 2. Success rate and number of respondents to on-line quizzes across webcasts.

3 EFFECTS ON STUDENT QUESTIONS

Before the course reform in 2013/2014, the students did not pose a single question in relation to the contents presented during the webcasts. The questions were instead all related to the contents directly coupled to the home assignments. Since the course covers many more aspects, the objective of the second course reform was to trigger questions also on the contents presented during the webcasts.

After the second course reform, the teachers received 39 questions on aspects of the course not related to the home assignments. Although a large fraction (58%) of these questions was of an administrative character, the increase in the number of questions indicates that the measures implemented during the second course reform did actually result in easier students-teachers interactions.

The remaining fraction (42%) of the questions was categorized using the revised version of Bloom's taxonomy for the cognitive domain [5]. The result is presented in Fig. 3. It can be seen that the on-line quizzes triggered questions at a much higher level of understanding than simply remembering the concepts, covering all levels of the cognitive domain, except "creating". (This highest level was reflected in the questions posed by the students in connection to the home assignments, but it is not part of the analysis reported in this paper.) Most of the questions posed by the students belong to the "understanding" level, followed by the "analysing" level and the "evaluating" level.

[2] In extremely few occasions, some of the active students did not actually answer some quizzes.

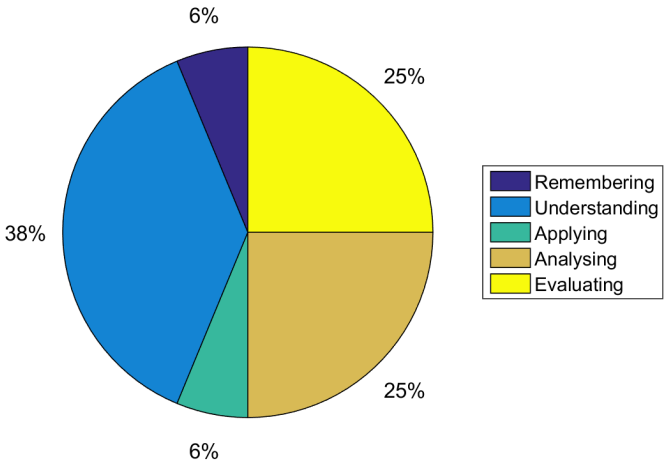

Fig. 3. Categorization of student questions using Bloom's revised taxonomy.

4 EFFECTS ON WEBCAST VIEWING

The effects of the course reform in 2013/2014 on webcast viewing can be seen in Fig. 4 – Fig. 6. Fig. 4 represents the average watching time for the different webcasts, defined as the total watching time for each webcast divided by the total number of views for the respective webcast. A slight increase of the average watching time is visible for most of the webcasts in the first half of the course. An integral parameter easily allowing a comparison of the two versions of the course is the average watching time for all webcasts. For 2012/2013, this parameter was 885 min, whereas for 2013/2014 (webcast #18 excluded), this parameter was 963 min. It can thus be concluded that the second course reform led to an increase in the average watching time, with a relative increase of 9%.

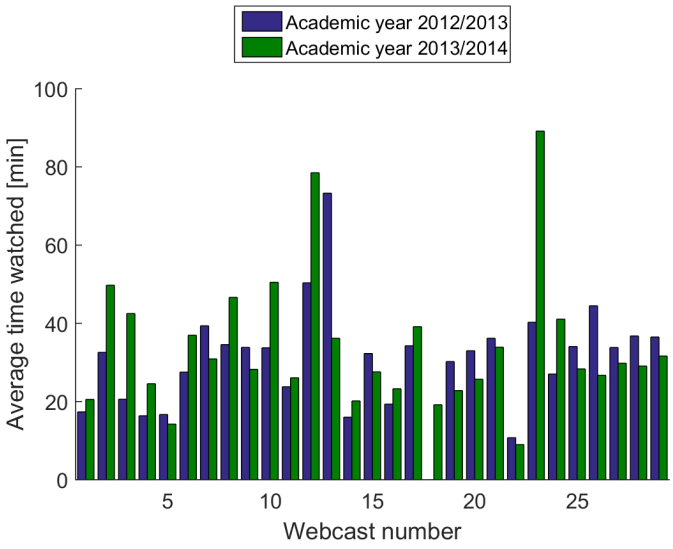

Fig. 4. Average watching time across webcasts.

Because of the significant drop in the number of total students during the course, it is interesting to look at the statistics for active students only. Fig. 5 presents the watching time per webcast and active user for the different webcasts. This time is calculated by dividing the active students' watching time for each webcast with the duration of each webcast and with the number of active students. Here too, the second course reform led to an increase in the watching time for most of the webcasts. Summing all webcasts together to get a simple integral measure of the two distributions, one obtains a value of 33.9 for 2012/2013 and a value of 35.6 for 2013/2014 (webcast #18 excluded), thus representing a relative increase of 5%.

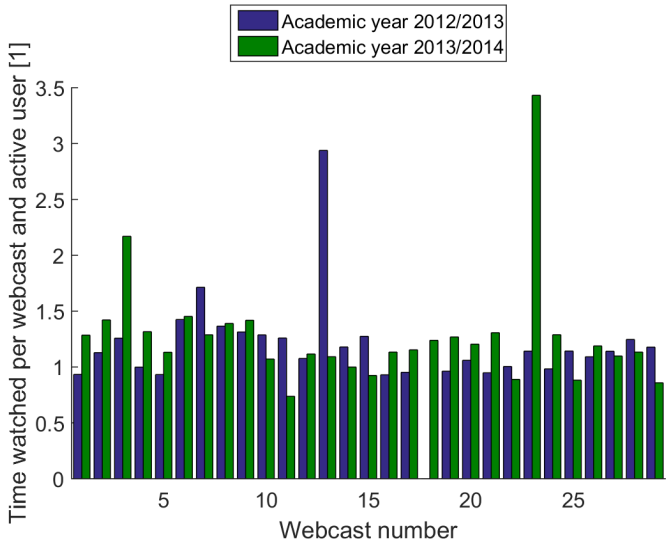

Fig. 5. Watching time per webcast and active user across webcasts.

Finally, Fig. 6 presents the number of views normalized to the number of users for the different webcasts, defined as the total number of views during each webcast divided by the total number of users for each of the webcasts. Whereas the denominator is given as one parameter per webcast, the total number of views is, on the other hand, estimated along each webcast as a function of the cumulative time the users watched the respective webcasts.

Fig. 6 thus offers a unique opportunity, compared to Fig. 4 and Fig. 5, to analyse the behaviour of the users while they watched the webcasts. The normalized number of views is clearly higher after the second course reform. It demonstrates that the on-line quizzes led to an increase in the normalized number of views. This is confirmed by integrating with respect to the cumulative time the normalized number of views. For 2012/2013, this integral was 6.23×10^5 views.min, whereas for 2013/2014, it was 8.45×10^5 views.min (webcast #18 excluded), thus representing a relative increase of 36%.

It can be clearly seen for the first third of the webcasts that the normalized number of views within each webcast was rather steady for 2012/2013. On the other hand, the second course reform led to the existence of different plateaus within the different webcasts, with decreasing trends in between. Such plateaus are best visible during the long webcasts, and the jumps between two consecutive plateaus within a given webcast seem to correspond to when the students are asked to answer given questions in the on-line quizzes. It thus indicates that too long webcasts, even if split up by on-line quizzes, lead to a drop in the number of views.

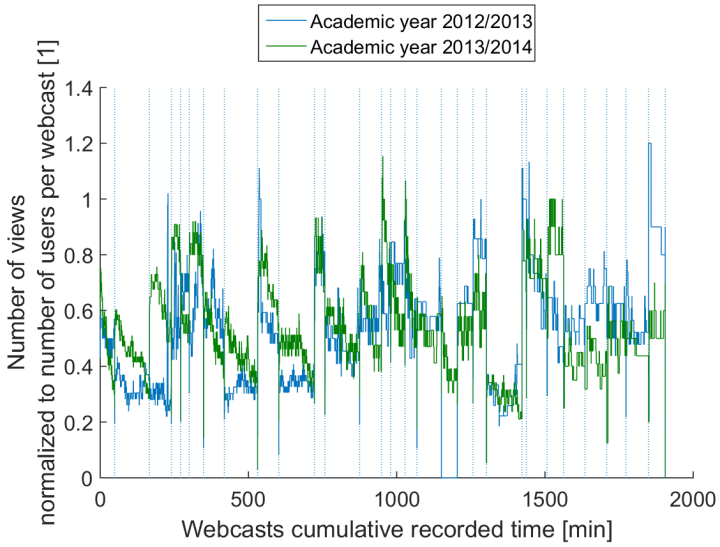

Fig. 6. Number of views normalized to the number of users across webcasts. Vertical dashed lines delimit each of the 29 webcasts.

5 CONCLUSIONS

This paper uses learning analytics to demonstrate that the introduction of on-line conceptual quizzes, together with the possibility to pose questions while watching the webcasts, increases the number of questions posed by the students. We also found that the level or quality of the questions increases, reflecting a deeper understanding of key concepts. This was also noticed during the wrap-up sessions. Moreover, the conceptual nature of the questions in the quizzes triggers more across-the-course integrative questions from the students compared to the questions by the students when solving the home assignments. Finally, the on-line quizzes were found to increase students' watching time for the webcasts, although too long webcasts, even if split up by several on-line quizzes, lead to a drop in the number of views. It should be pointed out that these conclusions are based on a relatively low number of active students.

This study highlights, in particular, the importance of using on-line quizzes in tandem with the pre-recorded lectures to encourage students to take a deep approach to learning when implementing flipped classroom models [8]. For courses having a relatively large number of students, the number of questions to be managed can rapidly grow out of proportions. An interesting strategy for dealing with this challenge is to let the students discuss selected questions in the discussion forum, thus also strengthening the element of peer interaction. This strategy will form the starting point for the third cycle of the action research project to improve teaching and learning in the course on nuclear reactor modelling.

REFERENCES

[1] Case, J. and Light, G. (2011), Emerging methodologies in engineering education research. *Journal of Engineering Education*, Vol. 100, No. 1, pp. 186-210.

[2] Demazière, C. and Jareteg, K. (2014), Developing a course in nuclear reactor modelling and going from campus-based to web-based teaching, Proc. of PHYSOR 2014 – The Role of Reactor Physics Toward a Sustainable Future, Kyoto, Japan, September 28 – October 3, 2014, on CD-ROM.

[3] Watkins, J. and Mazur, E. (2010), Just-in-time teaching and peer instruction. In Simkins, S. and Maier, M. (Eds.) *Just-in-time teaching: Across the disciplines, and across the academy*, Stylus Publishing.

[4] Hewitt, P. (1983). The missing essential: A conceptual understanding of physics. *American Journal of Physics*, Vol. 51, No. 4, pp. 305-311.

[5] Anderson L.W. et al (2000), *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*, Pearson, Allyn & Bacon.

[6] Biggs, J. and Tang, C. (2011), *Teaching for quality learning at university: What the student does*, McGraw-Hill Education (UK).

[7] Ramsden, P. (2003), *Learning to teach in higher education*, Routledge Falmer.

[8] Bishop, J. and Verleger, M. (2013), The flipped classroom: A survey of the research. Proc. of ASEE National Conference, Atlanta, GA.