DIGITAL TOOLS FOR SELF_STUDY AND EXAMINATION

Ksenia Onufrey, Martina Berglund, Dzamila Bienkowska, Thomas Magnusson, Charlotte Norrman

Department of Management and Engineering, Linköping University, Linköping, Sweden

ABSTRACT

Digitalization and increased use of information and communication technology (ICT) are major change processes taking place in engineering education today. Self-study and examination are areas with high potential for beneficial use of digital ICT tools. Some advantages with such tools are that students' can continuously assess their own learning in relation to the course objectives while they also can provide an opportunity to meet the teachers' needs to control how the students absorb the course material. Moreover, automatic provision of quick or instant feedback through digital tools can stimulate students' commitment and active learning and allow students greater flexibility in their learning process, with tests that can be conducted online regardless of time and space and can be repeated as needed. The purpose of this paper is to investigate how different types of ICT-based self-study and examination practices can be implemented in courses on topics such as project management, product development, and entrepreneurship, and build a knowledge base necessary for future systematic implementation of digital examinations. Our study is based on an educational development project at Linköping University, where we tested and evaluated different models and approaches for digital knowledge testing in a number of selected courses. We discuss both positive and potentially problematic aspects of the use of digital tools and conclude that successful implementation is dependent on well-planned integration of such tools into the overall course where different types of activities enhance each other. Thus, this study connects the areas of digital self- study and examination and provides examples of first steps on the way towards implementation of ICT-based examination practices.

KEYWORDS

Digital tools, ICT-based self-study, self-assessment, Standards: 8, 11.

INTRODUCTION

Digitalization and increased use of information and communication technology (ICT) are major change processes taking place in engineering education today. While the use of ICT helps solve a number of problems, it also brings new challenges (Mostert & Quinn, 2009). One area with high potential for beneficial ICT use is digital examination. Digital exams are already being implemented at Swedish universities and initial tests show positive results from both the teachers' and the students' perspectives (Berggren, et al. 2015). At the same time, changes in

the examination should be carried out without compromising the overall course design and logic (Biggs, 2003), and therefore require carefulness and coherence (Bertheussen, 2014).

One way to ensure gradual and continuous implementation of digital tools in connection with examinations is to start with digital self-study. By making both students and teachers more comfortable using ICT-based knowledge testing, and collecting experiences about how such tests can be constructed and how they are received and used, the way for digital examinations is being prepared in a thoughtful way.

Digital tools can be used to help meet students' needs to continuously assess their own learning in relation to the course objectives. At the same time, digital tools might help to meet the teachers' needs to see how the students absorb the course material in order to adapt their teaching. Moreover, the automatic provision of quick or instant feedback through digital tools can stimulate students' commitment and active learning. Also, students are allowed greater flexibility in their learning process, with tests that can be conducted online regardless of time and space and can be repeated as needed.

The purpose of this study is to investigate how different variations of ICT-based self-study and examination can be implemented in courses on topics such as project management, product development, and entrepreneurship, and build a knowledge base necessary for future systematic implementation of digital examinations. Our study is based on an educational development project at Linköping University, where we test and evaluate different models and approaches for digital knowledge testing in a number of selected courses.

ICT-BASED SELF-STUDIES

The use of digital tools in higher education is expanding. Different kinds of ICT-based tools have shown to improve learning processes and results, i.e. by enhancing students' self-monitoring and problem-solving skills (Ang, et al. 2012; Muianga, et al. 2018). Another factor contributing to the success of these tools is the flexibility in using them as they can be accessed anytime and anywhere, given a working internet connection (June & Leong, 2006). Importantly, the use of such tools results in more active student engagement (Ang, et al. 2012) and enable the shift from teacher centred learning (where learning is accomplished thanks to a teacher who conveys knowledge) to student centred learning (where learning is the result of knowledge construction by students) (Muianga, et al. 2018). Thus, the continued and growing use of digital tools is well in line with the CDIO focus on active learning (cf. Standard 8 – Active Learning) and with the overall philosophy of promoting more effective and exciting engineering education and stimulating deep learning (Crawley, et al. 2011).

One implication of the diffusion of the student-centred approach and active engagement is the increased use of digital tools for self-study. Some of those tools, such as video lectures, are incorporated into teaching activities, while others, such as digital self-assessment tools, are also related to examination practices. Below we discuss different types of digital self-study tools in more detail.

The use of digital lecture materials has been documented in several studies (e.g. Ang et al., 2012; Bhadani et al., 2017; Viksilä, 2013). Those include both audio recordings, powerpoint presentations with audio commentaries and full video lectures (Ang et al., 2012). A number of positive effects of integrating digital lectures have been discussed, such as enhanced understanding of concepts, decreased dependency on teachers and overall higher appeal for

students compared to traditional lectures (Bhadani et al., 2017). Although they lack an interactive component, digitalized lectures are viewed as a step on the way towards student-centred personalized learning (Bhadani et al., 2017). From the teachers' perspective, digitalized lectures are perceived as more time efficient which frees up resources to other types of support for students' learning (Viksilä, 2013).

However, digital lectures need to be carefully integrated into the course curriculum and used in combination with other traditional and digital tools. One specific issue discussed with regard to digital lectures is the lack of immediate feedback possibilities (Bhadani et al., 2017). This issue can be at least partially overcome by using another type of digital self-study tools considered in this paper, digital self-assessment tools.

Digital tools for self-assessment are a part of the course's overall assessment strategy which is crucial for student learning and motivation (Heap, et al. 2004). Digital self-assessment tools are often implemented in a form of web-based tests for practice, including a variety of question formats (multiple-choice questions, matching options from different lists, drag and drop questions, answers provided in input boxes) (Heap, et al., 2004). Digital self-assessment tools have the overall advantages of ICT-based methods, such as flexibility, interactivity, and time-efficiency. Apart from that, they can (although not obligatory) be viewed as a preparatory stage before introducing digital examination which also has shown very promising potential for both students and teachers (Berggren, et al. 2015). Thus, both the development of digital tools for self-assessment and digital examination methods correspond well with the CDIO Standard 11, Learning Assessment, which underline the need for a variety of assessment tools to ensure greater assessment confidence.

However, it can be noticed that the use of digital self-assessment tools has been overshadowed in existing research where most attention has been given to other digital tools for learning and examination. Therefore, one of the contributions of this paper is to provide a broader empirical base for the use of digital self-assessment tools.

Another example of ICT-based tool for self-studies are MOOCs. The first Massive Open Online Course (MOOC) was developed and offered in the late 2000s by Canadian professors (Blackmon & Major, 2017) and since then there has been an increasing interest in and development of MOOCs. Common features of MOOCs are (ibid, referring to Major & Blackmon, 2017):

- Massive: No limits of participants and the courses could potentially have large numbers attending.
- Open: Often free and accessible to anyone.
- Online: Offered online.
- Courses: No credits are offered. However, the courses have specific content and often a syllabus or some other structure for elaborating the course material. There are often assignments and self-assessments.

Integrating parts of MOOCs in university courses offers both advantages and drawbacks. Earlier studies have reported advantages, such as the possibility for blended learning and self-paced learning for students (Bruff, Fisher, McEwen, & Smith, 2013). Offering the students different types of course contents has also resulted in richer discussions among the students, and the teachers may redesign courses without developing online material themselves (Israel, 2015). A main challenge in integrating MOOC-material in university courses is the difficulty to

match the online material with activities in class and embed the material in the university course (Bruff et al., 2013).

IMPLEMENTATION CASES AT LINKÖPING UNIVERSITY

Digital tools during lectures

One possible way of using digital tools is through quizzes during lectures. In order to implement such an activity, the teacher needs to first create one or several questions that can range from simple yes or no questions to multiple choice or open-ended questions. Questions and answer options are then entered into a digital tool such as Mentimeter, Kahoot or Socrative. During a lecture, the teacher asks the students to answer the questions on their mobile devices. Provided answers can be presented and discussed with the students immediately. We have used these tools for analytical exercises as well as rehearsal exercises during lectures. Thus, digital tools can help to turn the lecture into an interactive event and can stimulate discussion of the course content. Furthermore, short written answers to open-ended questions can be collected in an efficient way through this method – both to questions regarding the course content or to evaluative questions regarding teaching methods etc. Furthermore, questions for such exercises can be viewed as one step in collecting a questions bank for future digital examinations.

Online courses in project management and entrepreneurship

Since 2011 we have run distance and semi-distance courses at our department. Our first such course was 'ETE324 Entrepreneurship' which focused on entrepreneurship in the healthcare sector. In this course, all lectures were given on distance. During the first years, they were given live at scheduled timeslots using Adobe Connect. Adobe Connect is a platform that is useful for these purposes as it allows the teacher to monitor the lecture, give the students an opportunity to write questions, speak or even show own presentations. Furthermore, the faces of the presenter(s) and participants could be displayed as well as PowerPoints or desktops. This software can also be used for more open online seminars and meetings. Through Adobe Connect, the lecture can also be recorded. Alternative platforms for this type of lectures include Skype, Discord or Microsoft´s Teams. In this case, during the first years the course was run only partly on distance and the students had to come to the university for an examination day where exams were written, and group assignments were presented. During the latter years (it was run for the last time during the spring 2017 and is now winded up), it was given fully over distance. Since 2015 online lectures are provided using the platform online Lisam. Another change was the move (in 2015) from live to recorded lectures created in the software Camtasia.

Today, we run two distance courses, one in Project management (TEIO91) that is a 90% distance course and one in entrepreneurship (TEIO05) that is a 50%-distance course. TEIO91 is run the same way as we run ETE324, i.e. with video lectures, online assignments and a final exam at the university. TEIO05 uses more of a 'flipped classroom' approach, which means that all lectures are recorded and available at the course web, while all seminars (which follow the lectures) are teacher-led. In both courses, we use 'discussion boards' instead of teacher-led traditional seminars on assignments. Students are also given direct feedback from the teachers on their assignments.

Knowledge tests have been used in our distance courses. In TEIO91 the students had to come to the university and conduct a written exam as in normal courses. The same holds for TEIO05,

historically, but this spring (April 2019), we used an electronic exam, where the students could sit at home and make their test online. The basis of this online exam was originally developed in ETE324. It consists of a bank of about 50 questions with alternative answers. Alternatives are designed either as 'radio buttons' where only one alternative can be chosen or as multiple-choice where several alternatives can be chosen. The grading is set up so that the question is worth one or several points depending on its complexity. Regarding the grading of the radio buttons, it is set up so that the right answer is given 100% of the assigned points and the wrong alternatives are given 0%. Regarding the multiple-choice percentages, points are given according to the number of right alternatives which implies that e.g. two correct alternatives give 50% each, while two incorrect alternatives give -50% each. This implies that a student that has picked two right alternatives and one wrong will get 50% of the total points assigned to the questions. To prevent students from cheating the test is designed so that each student is given 20 random questions out of the total 50. The questions are also grouped into categories and these are in turn weighted so that every area of the course gets represented among the randomly given questions. This test has also been used for training purpose/self-assessment in current non-distance entrepreneurship courses.

We have not yet obtained quantitative data on this examination practice from course evaluations since the courses are still ongoing. However, we have asked the students for their opinion. In TEIO05, where the online test is a part of the individual examination, students highlight that the online test fulfils its purpose and that it is convenient and flexible. Moreover, it is perceived as less demanding than a usual classroom exam, but due to the time constrain (30 minutes) the students could feel stressed during the exam even though they were able to complete the test with a good margin to the time limit. The use of the test for self-study purpose is appreciated as a good learning tool since it helps to draw attention to important areas of the course and provides an understanding of what type of questions that may appear in a written test.

Using MOOC-material for self-study in courses in product ergonomics

The MOOC-course 'Work and Technology on Human Terms' (www.onhumanterms.org) was introduced in August 2017 as a complement to the earlier published book (Bohgard, et al. 2011). The course was developed by the publishing company Prevent in collaboration with five Swedish Universities of Technology to achieve a modern highly accessible study material in Ergonomics. It encompasses 20 hours of study, which can be carried out whenever suitable for the student. The course includes theories and models supported with animations, interviews with experts and knowledge tests. The content of the MOOC is directly related to different types of businesses, which is reflected in interviews with product developers, managers and safety representatives. A further description of the MOOC-course is found in Lagerström, et al. (2017).

The MOOC material was used in two courses in Product Ergonomics in the form of suggested voluntary, alternative material for the students' self-studies and in one course also as mandatory, selected course material that was discussed in follow-up seminars. In the case of suggested voluntary course material, the content and structure of the MOOC were introduced during lectures. The students were then recommended to use the MOOC if and as they wished. In the other case, specific parts of the MOOC-material was mandatory. There were assignments in which the MOOC-material was elaborated by the students and later discussed in seminars. For a further description of the uses of the MOOC course, see Osvalder & Berglund (2018).

An evaluation of the use of the MOOC-material showed that the students found the material relevant for their studies. It was considered as a good introduction to Ergonomics. Some students found the material too shallow for specialization. However, depending on what was in focus in the different courses in product ergonomics, the corresponding parts in the MOOC-material was found most valuable. In general, the students selected different parts of the MOOC. The MOOC-material was used in different ways. Some students considered the MOOC as a complement to the literature, others considered it sufficient to pass the examination. It was also used as a back-up if the students had missed a lecture. The students further pointed out the advantage of being able to use it whenever suitable for the student and at one's own pace.

DISCUSSION

In our experience, there are several benefits of using digital tools in teaching, but there are also a number of challenges. Using digital tools to integrate quizzes into lectures can make traditional lectures more interactive. This is especially valuable when addressing large student groups. Engagement and interactivity are stimulated as every student with a mobile device can participate anonymously and test their own knowledge without being forced to reveal to others whether they are right or wrong. It also gives the teacher an opportunity to identify parts of the course content that students find difficult as well as parts that are well known to the students already. Each student that participates gets an individual sense of which parts of the material they know well and which parts they need to study further. Even when answering correctly a student receives instant confirmation of their knowledge – this is important since the provision of positive feedback can otherwise easily be overlooked by busy teachers. Additionally, this type of activity means that mobile devices are used in a positive and beneficial way in the classroom. The use of digital tools for quizzes and questions ensures manageability of collected data, and taking time to do this during lectures might lead to a higher participation rate than other methods such as sending out a survey or providing questions on the course website. The use of quizzes in lectures can be viewed as an intermediate alternative between traditional lectures and video lectures. While making a step towards using digital tools, the lectures not only retain but even increase interaction, thus managing to overcome the issue of fully digitalized lectures as discussed in previous literature (Bhadani, et al. 2017).

With regard to online courses, interaction is more challenging. Simply putting up an interactive newsfeed or a discussion board is not enough – our experience is that such tools are not used spontaneously. So, to facilitate interaction and discussions we need to provide clear requirements, e.g. a minimal number of posts and comments to which each student is supposed to contribute. It is also of importance to assign clear subjects for discussion, e.g. a specific assignment or an area from the literature. It is also beneficial if the teachers engage in the discussions themselves since this provides recognition and makes the students aware that their comments are also read by teachers. Engagement in such discussions is an example of new ways of supporting students' learning that become possible through digital tools and how teachers' time can be shifted from delivering lectures to other activities since pre-recorded lectures can be re-used (cf. Viksilä, 2013).

Group work during campus-based courses is often most beneficial since it involves mutual learning and interaction. However, we have identified that in online courses, and especially in cases where the courses are electable, group work is risky. This is the case since the teacher lacks control over the students and their work and thereby cannot aid in time when problems arise. When group work cannot be used teachers should consider facilitating other forms of

interaction between students since this should be an integral component even in online courses.

When designing lectures for distance courses there is always a risk that recorded lectures become impersonal, because the lecturer is invisible. This could be remedied by showing the teacher's face in the webcam during the start of a lecture. After the introduction, the webcam can be turned off and focus can be put on the slides. Showing the teacher's face again at the end makes the student connect the lecture to the teacher. Our experience thus shows that it is beneficial to combine different types of digital lectures (both powerpoint presentation with audio commentaries and video lecture) (cf. Ang, et al. 2012).

Compliance with the intended time plan for a course is another challenge. In distance courses, there is always a risk that students save the work for later and then ends up in panic and failure as time passes by. That is one of the implications of flexibility provided by digital tools (cf. June & Leong, 2006). To remedy this, we recommend a stepwise approach, where a sequence of assignments builds upon each other. By structuring the course like this, the students are given the incentive to be active from start to end. This way the benefits of student centred learning (Muianga, et al. 2018) can be maximized. Finally, to succeed in online courses a well-functioning, stable and flexible online platform is needed. In our case, our university has built its own platform based on office 365, which allows for stability and multiple functions. Use of the platform requires an investment in the form of time for learning about all the features but is rewarded through being able to use a variety of functions.

CONCLUSIONS

The purpose of this study was to investigate how different types of ICT-based self-study and examination practices can be implemented in courses on topics such as project management, product development, and entrepreneurship, and build a knowledge base necessary for future systematic implementation of digital examinations.

We have tested several digital approaches in our courses and our overall conclusion is that digital tools are beneficial in terms of increasing the level of activity among the students and for activities such as self-study and self-assessment, which make them highly relevant within a CDIO-based education.

Based on our experiences, we would like to conclude the following:

- Digital tools, such as quizzes, are an efficient way to raise the activity level and facilitate learning during teacher-led activities in the classroom
- Provision of online content such as MOOC-material for self-study or video lectures is beneficial in many ways but requires complementary activities that enhance interaction among students – especially for courses that are given entirely online
- A well-functioning and flexible digital platform is a prerequisite when using digital tools for self-study
- Campus-based courses can be improved by implementing features used in online courses
- Online tests with multiple choice questions seem to work both as examination tool (maybe not as a main tool though) and as a tool for self-studies.

To start with the first point, the use of digital tools such as quizzes during teacher-led classroom activities is beneficial not least since the ICT-tool can be used as an intermediate between the teacher and the students. During traditional seminars, students may feel exposed when answering questions and this can, in turn, imply that they prefer to keep quiet and thereby withhold answers or comments that they might have. This can work against their learning.

During fully digitalized lectures however, the teacher cannot interact with the student at the same type of instant level, which in turn makes the learning less efficient as the process becomes slow. This entails that for such circumstances, other strategies for the creation of interaction are needed, e.g. discussion boards with clear requirements on the level of engagement.

The second point, the online lectures are efficient by means of flexibility for both teacher and students, however the interaction with the students is a challenge as video lectures tend to be impersonal. The communication is also in one direction instead of being mutual. Some of these problems can be remedied by making the lectures more personal, through e.g. showing faces on the film, or adding discussion boards. It could also be solved by following up the video lectures in classroom activities such as teacher-led seminars. This model used in our entrepreneurship courses and in these cases the video lectures are part of a flipped classroom approach where the videos help the students to 'conceive' and the teacher-led workshops helps them to 'design' and 'implement'.

Regarding digital platforms for education, a well-functioning system is a prerequisite. Essential functions are communication interfaces such as information feeds that allow for communication between teachers and students and the ability to upload documents and hand in and mark exams in a convenient way. Video channels, possibility to create own pages, discussion fora, group rooms and so on are other features that enable e-learning. Having access to a good education platform entails that the pedagogic structure of online courses could be implemented also in the campus-based courses. This is beneficial as it gives the students opportunity to blended learning, which has shown to enhance learning.

Finally, online tests are an interesting area for further development. The experiences gathered have encouraged us to continue this work. From a teacher perspective, there is a learning threshold regarding how to design such tests, but when working they can give a good picture of the student's level of knowledge and they can save time as they are automatically corrected.

REFERENCES

Ang, C. K., Embi, M. A., & Yunus, M. M. (2012). Incorporating ICT tools in an active engagement strategy-based classroom to promote learning awareness and self-monitoring. *International Education Studies, 5*(4), 139.

Berggren, B., Fili, A., & Nordberg, O. (2015). Digital examination in higher education-Experiences from three different perspectives. *International Journal of Education and Development using Information and Communication Technology, 11*(3), 100.

Bhadani, K., Stöhr, C., Hulthén, E., Quist, J., Bengtsson, M., Evertsson, M., & Malmqvist, J. (2017). *STUDENTS PERSPECTIVES ON VIDEO-BASED LEARNING IN CDIO-BASED PROJECT COURSES.* Paper presented at the Proceedings of the 13th International CDIO Conference, Calgary, Canada.

Biggs, J. B., & Tang, C. S.-k. (2011). *Teaching for Quality Learning at University : What the Student Does*. Maidenhead: Society for Research into Higher Education & Open University Press.

Blackmon, S., & Major, C. (2017). Wherefore Art Thou MOOC: Defining Massive Open Online Courses. *Online Learning Journal, 21*(4).

Bohgard, M., Karlsson, S., Lovén, E., Mikaelsson, L.-Å., Mårtensson, L., Osvalder, A.-L., Rose, L. & Ulfvengren, P. (2011). *Work and technology on human terms*, Stockholm: Prevent.

Bruff, D. O., Fisher, D. H., McEwen, K. E., & Smith, B. E. (2013). Wrapping a MOOC: Student perceptions of an experiment in blended learning. *Journal of Online Learning and Teaching, 9*(2), 187.

Crawley, E. F., Malmqvist, J., Lucas, W. A., & Brodeur, D. R. (2011). *The CDIO syllabus v2. 0. An updated statement of goals for engineering education.* Paper presented at the Proceedings of 7th International CDIO Conference, Copenhagen, Denmark.

Heap, N. W., Kear, K. L., & Bissell, C. C. (2004). An overview of ICT-based assessment for engineering education. *European Journal of Engineering Education, 29*(2), 241-250.

Israel, M. J. (2015). Effectiveness of integrating MOOCs in traditional classrooms for undergraduate students. *The International Review of Research in Open and Distributed Learning, 16*(5).

June, H. T., & Leong, H. (2006). Implications of E-Learning on Learning and Teaching in Higher Education. *2nd International CDIO Conference, Linköping, Sweden*.

Lagerström, G., Bohgard, M., Eklund, J., Mikaelsson, L- Å., Osvalder, A-L., Rask, K. & Tikka, D. (2017). Development of the online course "Work and Technology on Human Terms". *Proceedings for NES 2017 Joy at Work, Lund, Sweden*.

Mostert, M., & Quinn, L. (2009). Using ICTs in teaching and learning: Reflections on professional development of academic staff. *International Journal of Education and Development using ICT*, 5(5), 72-84.

Muianga, X., Klomsri, T., Tedre, M., & Mutimucuio, I. (2018). From Teacher-Oriented to Student-Centred Learning: Developing an ICT-Supported Learning Approach at the Eduardo Mondlane University, Mozambique. *TOJET: The Turkish Online Journal of Educational Technology, 17*(2).

Osvalder, A-L. & Berglund, M. (2018). On Human Terms – Integration of a Massive Open Online Course (MOOC) in Ergonomics in University Courses. *Proceedings of the 20th Triennial Congress of the IEA, Florence, Italy.*

Viksilä, R. (2013). Effectiveness of Video Lecturing Technology in ICT Learning. *Proceedings of the 9th International CDIO Conference, Massachusetts Institute of Technology and Harvard University School of Engineering and Applied Sciences, Cambridge, Massachusetts*.

BIOGRAPHICAL INFORMATION

Ksenia Onufrey is a Lecturer at the Division of Project, Innovation and Entrepreneurship, Department of Management and Engineering at Linköping University, Linköping, Sweden. She is active in teaching in different courses in project management, innovation management, organization and leadership. Her main research interest is innovation processes in mature industries.

Martina Berglund, Ph.D. is an Assistant professor at the Division of Logistics and Quality Management, Department of Management and Engineering at Linköping University, Linköping, Sweden. She is the director of the Human Factors Network in Sweden and a co-ordinator at HELIX Competence Centre at Linköping University. She collaborates in teaching with KTH Royal Institute of Technology and the School of Engineering at Jönköping University. Her research focuses on ergonomics/HTO in different fields, quality development and management, and visualization and learning.

Dzamila Bienkowska is an Associate Professor in industrial organization at Linköping University, Sweden and her main teaching activities are within courses in project management and industrial organization. Her main areas of research are academic entrepreneurship and regional development.

Thomas Magnusson is a Professor in Industrial Management, affiliated at the Department for Management and Engineering, Linköping University in Sweden. He teaches in innovation and project management. His research interests relate to environmental innovation and socio-technical transitions.

Charlotte Norrman is an Associate Professor in industrial organization at Linköping University, Sweden and her main teaching activities are within courses in entrepreneurship. Her main area of research is entrepreneurship and innovation.

Corresponding author

Dzamila Bienkowska
Linköping University
Department of Management and Engineering
SE-58183 Linköping, SWEDEN
+46-(0)13-284427
dzamila.bienkowska@liu.se