THE DESIGN AND USE OF OPEN ONLINE MODULES FOR BLENDED LEARNING IN STEM TEACHER EDUCATION

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Blended learning, a teaching format in which face-to-face and online learning is integrated, nowadays is an important development in education. Little is known, however, about its affordances for teacher education, and for domain specific didactical courses in particular. To investigate this topic, we carried out a design research project in which teacher educators engaged in a co-design process of developing and field-testing open online learning units for mathematics and science didactics. The preliminary results concern descriptions of the work processes by the design teams, of design heuristics, and of typical ways of collaborating. These findings are illustrated for the case of two of the designed online units on statistics didactics and mathematical thinking, respectively.

Keywords: blended learning, design teams, mathematics education, STEM, teacher education

INTRODUCTION

In august, 2015, a new curriculum for mathematics in upper secondary education (grades 9-12) was introduced in the Netherlands. Among others, this curriculum has a stronger focus on mathematical thinking and on new approaches to statistics education, based on data sets made available through the use of ict. The crucial factor in curriculum innovation, however, is to make these innovations impact on classroom practice (Anderson, 1997; Fullan, 2007).

Obviously, there is a responsibility for in-service teachers, as well as for teacher education institutes. The former have to ensure that they are capable of teaching the new curricula adequately; the latter have to make sure that their students, being prospective mathematics teachers, are not only familiar with the new curricula, but also with ways of *how to* teach them. Exploiting the potential of information and communication technology still deserves special attention (Hegedus et al., 2017).

When addressing this 'how to', blended learning comes into play. Roughly speaking, blended learning means *blending* face-to-face education with online learning activities. Nowadays, more than twenty-five years after the introduction of the worldwide web as part of the internet (Berners-Lee, 1989), a staggering amount of digital resources for the teaching and learning of mathematics is available online. This leads educational designers and teachers to selecting, re-designing and arranging resources in order to orchestrate their students' learning (Drijvers et al., 2010). For the case of teacher education, however, and for courses on domain-specific didactics in particular, the affordances of blended learning remain largely unexplored.

In this paper we describe how online learning units for pre-service teacher education for secondary mathematics in a blended learning context are designed, implemented and evaluated by design teams. We describe the design of two specific units, one for mathematical thinking, the other for exploratory data analysis utilizing ICT. The results of using these learning units in pre-service teacher training will be available later this spring.

THEORETICAL FRAMEWORK

In higher education, blended learning has been on the rise since the early 2000's. With respect to terminology, quite a few buzz words came along. In fact, one might wonder if educational goals have fundamentally changed since researchers from the University of Illinois in 1960 utilized a mainframe computer with work stations for their students for computer assisted learning, which they called Programmed Logic for Automatic Teaching Operations (PLATO, see Woolley, 1994). Terminology evolved from computer-assisted (or -based or -supported) learning to intelligent tutoring systems (Anderson, 1995), E-learning (Clark & Mayer, 2008), with blended learning as a popular teaching approach nowadays (Bonk & Graham, 2006). In retrospective, all terminology boils down to roughly the same issue, i.e., how to arrange the educational resources -including information and communication technology- into an educational design that optimizes learning? What we appreciate in the term 'blended learning' is that it explicitly points at the fact that there is more than one medium to be addressed when designing instruction.

From the perspective of learning theory, scientific insights have evolved as well: from the behaviourist view on human learning (Skinner, 1954), suitable for computer assisted mastery learning (Skinner, 1958), to the nowadays accepted social constructivist view, as initiated by Vygotsky (1962), which can be supported by a more open learning environment. Blended learning is a technological paradigm that suits this view on learning and teaching.

A major didactical issue with respect to blended learning is how to arrange the interplay between online and face-to-face mathematical activities, and how to co-design such arrangements. In this paper, we address this issue for the case of domain-specific didactics courses within pre-service mathematics teacher training. In this way, we address the following research question:

> How to collaboratively design, evaluate and disseminate digital blended learning units for mathematics teacher education?

METHOD

The context of this study is a small, one-year project granted by the Dutch ministry of education and supervised by SURFnet, the collaborative ICT organisation for Dutch education and research [1]. The aim of the project is to co-design, evaluate and disseminate four blended modules for pre- and in-service teacher training, and for domain specific STEM didactics in particular. In this paper we focus on the design of two of these units, one on the topic of mathematical thinking, and one on statistics didactics.

For each of the modules, a design team was set up. Each design teams consisted of three teacher educators: one from the HU University of Applied Sciences, one from Utrecht University, and one from another teacher training institute in the Netherlands. The latter would facilitate dissemination and bring in a wider view. Most of the designers were experienced teacher educators, but had limited experience with (the design of) blended learning resources.

As each of the designers had limited time for the project (like 40 hours over the whole period of one year), the coordinating team -this paper's authors- decided to organize short, intensive collaborative "boot camp" design sessions. During the fall of 2016, three of such one-day boot camps were organized, during which the design teams engaged in their co-design, but informal exchange between teams was also possible. Camera teams were available, as well as tools such as light boards for the production of video clips.

A collaborative online design environment was set up, so that the designers could continue their co-design activities between the boot camp sessions. The ICT environment was provided by Kennisnet, a Dutch semi-governmental organisation for ICT in education [2]. In this way, a blended design approach was made possible.

The different teams met during boot camp days to discuss overarching topics, such as module layout and structure, the guidelines for use that a teacher educator might use. During the design process, design heuristics and decisions were monitored. After the design period, the use of the blended modules will be field-tested in didactics courses by teacher educators all over the country, including co-designers and educators not involved in the design. To evaluate the experiences, the field tests will be monitored through pre- and post-interviews with the educators.

RESULTS

Unfortunately, as the monitoring process of the field tests is currently ongoing during spring 2017, its results will only be available in July. Therefore, we now focus on the design process, which we will describe subsequently for the two units, one on statistics didactics and the other on mathematical thinking.

Case 1: A learning unit on statistics didactics

As a first case of designing an open online learning unit for a blended course on mathematics didactics, we now briefly describe the design process of a unit on statistics didactics for pre-service teacher education. Based on general ideas on exploratory data analysis (Tukey, 1977) and the analysis of large data sets through the use of ICT, the statistics curricula have been reformed recently. Therefore, statistics didactics is an issue in teacher education and this explains the choice for this topic.

The design team consisted of two pre-service teacher educators and one professor in mathematics education. As the team members had not collaborated before so closely, the first day of the three-day design process was spent on getting to know each other and exploring the unit's theme. A joint dropbox folder had been created to exchange ideas and existing materials. It was noticed that many mathematics teachers, due to their education, only have limited knowledge about statistics and the new approach to it, so that some content knowledge should be intertwined with a pedagogical and didactical approach. As a consequence, the team decided to focus on core aspects of statistics, namely (1) Describe data, and (2) Beyond data.

During the second design boot camp, the outline was elaborated. In the Describe data part, particular attention is given to data visualization, levels of measurement, and statistical literacy. The Beyond data part focuses on correlation and causality, the interpretation of p-values, and of confidence intervals. These topics were selected because on the one hand, we expected them to be beneficial to teachers' content knowledge, and on the other hand we identified them as didactical challenges while teaching.

During the third and final design day, special attention was paid to design tasks for the teacher-students. Also, the team worked on the comments provided by an external review committee.

In the design process, a mix was made of existing resources such as video clips, text books, research papers, and newly designed resources such as tasks for teacher-students and guidelines for the teacher educator, and dedicated video clips. On the one hand, it made sense to make use as much as possible from existing resources. On the other hand, the need was felt to have dedicated resources that fit well to the specific Dutch situation and curriculum. Figure 1 shows a still of a new clip made

with light board technology. Figure 2 shows an extract of a dialog between Dutch mathematics teachers' Facebook group on a particular problem, which is used in the online learning unit to enhance discussion between students during the face-to-face part of the blended course.

The results of the design are available online [3]. As part of the ongoing design process, input from other teacher educators is expected to further improve and extend the unit in a collaborative way.

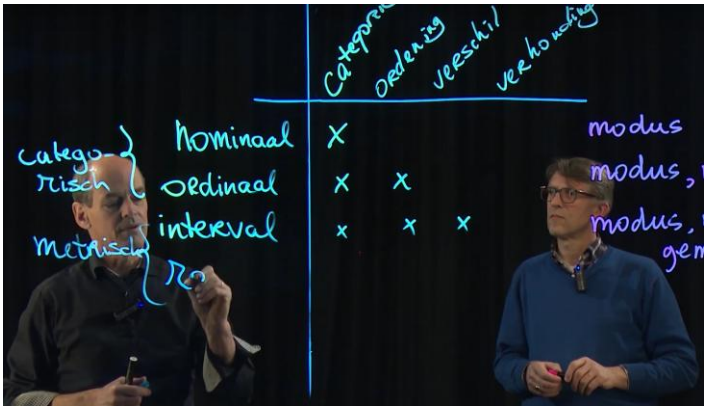

Figure 1. Still from a video made with light board technology

Figure 2. Copy of a dialog on the Dutch mathematics teachers' Facebook Group

Case 2: A learning unit on mathematical thinking

The second case we describe concerns an open online unit about didactics for fostering mathematical thinking. Attention to this topic is evident in the international research community (e.g., see Devlin, 2012; Schoenfeld, 1992) and was invigorated in the Netherlands by recent curriculum developments in Dutch secondary education (Drijvers, De Haan, & Doorman, submitted).

The team that designed the unit about mathematical thinking consisted of three teacher educators, all of whom had some prior experience with this topic. One of them also developed and taught a course on mathematical thinking as in-service training for teachers.

The outlines of the online unit were quickly decided on. One reason for this was that the members of the design team already had collaborated in different projects (although not about mathematical thinking) and also had shared ideas about the topic under concern. The unit was planned to consist of several self-contained student activities divided into three categories: (i) designing classroom tasks that stimulate mathematical thinking, (ii) supporting such classroom tasks in the classroom, (iii) assessing proficiency in mathematical thinking. Having established an outline, the ideas for the individual student activities emerged organically during the three boot camp days. Here follows an impression of this process.

During the first day the team focused on a key article (Swan, 2005) as inspiration for the design of the first student activity. This resulted in a small set of materials, including a video clip, and a guide for teacher educators how the material could be used. Figure 3 gives an impression. The day was further spent in selecting appropriate study materials from a large set that the design team had collected in advance.

During the second boot camp day, the idea emerged of using materials produced by some of the experienced teachers that had participated in the in-service training of one of the design team's members. Those materials consisted of a classroom exercise aimed at stimulating mathematical thinking and a description about how it worked out in practice. The team planned a filmed interview with one of those teachers and worked out ideas for four film projects. These film projects shared the same set-up: each focused on an exercise explicitly designed to stimulate mathematical thinking; and each consisted of a sequence of three clips A, B and C. Clip A showed two team members discussing the exercise before it was used in practice (see Figure 3). They tried to predict what kind of thought processes the question would evoke in pupils. Clip B was filmed inside a school building. A pupil was asked to work on the set question, and was then interviewed about the strategies he or she had used. Clip C showed the team members again, but now they reflected on their experiences with the pupils. The film projects were placed on the website together with suggestions for use in teacher education. The suggestions involved a choice for the teacher educator. He could either just use the clips B together with digital copies of the exercises, or use the whole series of clips modelling how to discuss potential thought provoking questions. In the former case, his students can predict and reflect on the quality of the exercises in a whole-class discussion. In the latter case, students can be given the task to try it out themselves with other (e.g., self-designed) exercises in their own classrooms.

Between the second and third boot camp day an external reviewing committee provided feedback on the site. Besides useful comments on usability, the remark was made that the important aspect of 'the culture of answer getting in mathematical classrooms' had been ignored. During the third boot camp, the team tried to deal with this by adding materials about experiences of working teachers. They also made a film interview with an expert on the subject.

The results of the design process are available online [4]. Input from other teacher educators is expected to further improve and extend the unit in a collaborative way.

Figure 3. An impression of the web site (in Dutch)

CONCLUSION

The research question is how to collaboratively design, evaluate and disseminate digital blended learning units for mathematics teacher education. At present, we can only draw conclusions with respect to the design phase. Results on the evaluation are expected in July, followed by results about dissemination in October. Concerning the design aspect, the preliminary conclusions fall into three categories: (1) the composition of design teams, (2) design heuristics, and (3) ways of collaborating.

The design teams were each composed of three experienced teacher educators from different institutes. In consequence, the team members could share experiences and materials. This resulted in a shared collection of existing materials that were already, but unknown or inaccessible outside individual institutes. The project was also instructive for the team members – both with regard to their personal subject knowledge (e.g., statistics didactics) as to blended learning skills (e.g., camera experience). A drawback of using mixed teams is that people need time to getting to know each other and to form a joint vision on the subject at hand. Although this is important for a fruitful collaboration, care must be taken that teams dwell too long in this phase. This leads to the first conclusion.

1. Small design teams of experienced teacher educators from different institutes leads to boundary crossing between institutes, resulting in (i) rich material and (ii) professional development of the educators themselves, although a pitfall is that (iii) too much time may be spent on discussion rather than on the actual design.

The most important design heuristics from the start were that we aimed at learning units which were open online and blended. ‘Open online’ implied that the materials would eventually be published on the web under a creative commons license [5]. Without any difficulty this turned out to be a tenable mind set, although extra care was given in using materials from others that could have copyrights on them. In practice, ‘blended’ meant that materials should at least encompass texts, film clips and descriptions for student activities. These student activities involved both classroom tasks supervised by a teacher educator and online tasks.

Other design heuristics emerged in the course of the process: we used mid-session intervals during the boot camps to discuss ideas and explicate some shared heuristics. The most important one that

emerged in this process concerned the target audience. In fact, two target groups were recognized: the student teachers and the teacher trainers. This was apparent in the materials: film clips, worksheets, etc. aimed at the former, guidelines and suggestions for use at the latter. But design teams had the teacher trainer in mind also in another way. A comparison was made with the way an educator uses a handbook, selecting exercises from it, skipping or supplementing content, etc. It was felt that this level of autonomy should also be provided in the learning units that were designed.

2. Digital blended learning units should be designed with both student teacher and teacher educators in mind. Toward teacher educators, a balance need be found between guidance on the one hand and autonomy on the other.

As explained above, we stimulated collaboration by organizing boot camps. These boot camps were intensive days of working in the design teams, apart from a plenary meeting at the start of the project and the aforementioned mid-session discussions during lunch. We facilitated the teams by setting a time and place and organizing technical support for the film clips. Teams sat together and worked in ways they could decide for themselves. This was successful: participants on the one hand experienced a large measure of autonomy – which, we belief, had a positive effect on their motivation – while on the other hand were encouraged to reserve three full days outside their usual working habitats. This last aspect could be the most difficult one to generalize, since we experienced that it is difficult to schedule days where everyone is available – especially in an extra-institutional context.

3. Scheduling design sessions were teams can collaborate for several hours with full focus on producing materials makes it feasible to construct digital blended learning units in a short time span. Readily available technical assistance during these sessions lowers the barrier for producing film clips.

These preliminary conclusions concern the design process. This spring, teacher educators throughout the Netherlands will field-test (parts of) the designed learning units. To monitor this, they fill in an online questionnaire beforehand, to assess their intentions and ideas. After the field test, they will receive a second questionnaire to assess their appreciation of the units as well as the ways in which they used them in practice. This will be followed by a limited number of interviews with some of these educators. Through the analysis of these data, we hope to be able to answer questions on the evaluation and dissemination of the learning units, and to extrapolate them to more general recommendations on the process of co-designing blended learning for teacher education.

NOTES

1. See https://www.surf.nl/en/innovationprojects/customised-education.html
2. See https://www.wikiwijsleermiddelenplein.nl/
3. For the current state of the unit (in Dutch) see http://maken.wikiwijs.nl/86112/Didactiek_van_statistiek
4. For the current state of the unit (in Dutch) see http://maken.wikiwijs.nl/85927/Wiskundige_denkactiviteiten
5. See https://creativecommons.org/licenses

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