Problem-Based Learning in a MOOC
Exploring an Innovative Instructional Design at a Large Scale

Daniëlle M. L. Verstegen, Annemarie Spruijt, Diana Dolmans and Jeroen van Merriënboer
Department of Educational Development and Research, Faculty of Health, Medicine and Life Sciences, Maastricht University, P.O. Box 616 (Visiting Address: universiteitsSingel 60), 6200 Md Maastricht, The Netherlands

Keywords: Massive Open Online Course, MOOC, Problem-Based Learning, PBL, Innovative Instructional Design, Collaborative Online Learning.

Abstract: This paper describes a MOOC about PBL which is designed –as far as possible in the setting of a MOOC- in line with modern learning principles that are also at the basis of PBL: constructive, contextual, collaborative and self-directed learning: *Problem-Based Learning: Principles and design. Students at the centre!* The course is centred around a set of authentic 'problems' organized in three different tracks (tutoring, designing, and implementing PBL) targeted at different types of participants. Small group work is essential in this MOOC. Students can either form teams themselves or be assigned to a team automatically. Each team has team space with chat facilities, file exchange, and facilities to schedule online meetings. However, teams can decide themselves how they want to collaborate and communicate, synchronously or asynchronously. A pilot study brought forward strong and weak points, which were used to further improve the design. This paper describes the pilot study, the changes made in the design and some first impressions of the first run of the MOOC. Preliminary conclusions are that MOOCs require careful instructional design. Stimulating online small group learning in a MOOC, i.e. following PBL learning principles to an extent but without tutors for each team, is possible, but not easy.

1 INTRODUCTION

Massive Open Online Courses (MOOCs) are a global trend that will potentially change the whole concept of higher education (Waldrom 2013; WUN 2013; Yuan and Powell 2013), however currently dominated by key players: Coursera (https://www.coursera.org/), EdX (https://www.edx.org/) and Udacity (https://www.udacity.com/). The UK Open University offers MOOCs at Futurelearn (https://www.futurelearn.com/courses). Within the Netherlands the trend of MOOCs is recognized by the government (Bussemaker 2013) and several MOOC initiatives are starting up, Delft University being most active up to now offering courses through EdX.

The term MOOC has been applied to a variety of online and blended courses (Hollands & Tirtaly 2014). Historically, so called 'cMOOCs' aim at facilitating learning through participant interactions with a network of individuals in which the teacher has a far less prominent role. Participants are encouraged to create, share, and build upon each other's artefacts. Another stream in MOOC development, however, aims primarily at delivering education at scale and involves more structured and sequenced direct transmission of knowledge.

Hollands and Tirtaly (2014) researched how the term MOOC is interpreted. The word 'massive' in MOOCs usually refers to a large number of participants. 'Open' usually refers to the possibility for anyone with adequate internet to participate in the course, typically also for free. Online refers to availability via the internet, and most agreed that, to be labelled a "course," MOOCs should be bounded by time, that is, have a beginning and an end point. It should provide a coherent set of resources; and follow a sequence of activities organized by an instructor in order to address specific learning objectives or goals.

Many existing MOOCs are criticized for lack of sound instructional design (e.g. Holton 2013). McAndrews and Scanlon (2013) stress that MOOCs require careful instructional design using lessons learned from other forms of distance education.

Verstegen, D., Spruijt, A., Dolmans, D. and Merriënboer, J.
Problem-Based Learning in a MOOC - Exploring an Innovative Instructional Design at a Large Scale.
In *Proceedings of the 8th International Conference on Computer Supported Education (CSEDU 2016) - Volume 2*, pages 369-377
ISBN: 978-989-758-179-3

Alternative ideas are being developed stressing learner participation and engagement (Ahn, Butler, Alam & Webster, 2013) and the development of connectivist MOOCs (cMOOC) (Mackness, Waite, Roberts and Lovegrove 2013; Morrison 2013).

Maastricht University (UM) has a strong tradition in Problem-Based Learning (PBL). PBL is a powerful student-centred educational approach, where learning is centred around authentic ill-structured problems (e.g., Barrows 2002; Barrows & Tamblyn 1980; Dolmans, De Grave, Wolfhagen & Van der Vleuten 2015; Moust, Bouhuijs & Schmidt 2014). PBL focuses at small-group learning centred around authentic problems. At first sight, this is in contrast with the large-scale and often teacher-driven set-up of MOOCs.

In a university wide project a MOOC about PBL was developed which is designed –as far as possible in the setting of a MOOC- in line with modern learning principles that are also at the basis of PBL: *Problem-Based Learning: Principles and design. Students at the centre!* (https://novoed.com/problem-based-learning/). The goals of this project were to evaluate an innovative PBL-based instructional design for MOOCs and to gain first-hand experience with MOOCs, and explore potential implications for Maastricht University and its students. More information about the project can be found at http://moocs.maastrichtuniversity.nl/.

This paper describes the design of this MOOC in relation to the principles of PBL, reports results of the pilot study, and first impressions of the first open run of the MOOC in October-December 2015.

2 DESIGN OF THE MOOC

2.1 Topic and Project Team

At the start of the project there were a few requirements: a university-wide project team, a topic in the area of education and learning, and a format in line with modern learning principles and the educational vision of the university. The project team consisted of 34 people, including representatives from all faculties: Health, medicine and life sciences, Law, Psychology and neuroscience, Business and economics, Arts and social sciences, and Humanities and sciences, and some student-assistants.

The project team decided to take PBL also as topic for the MOOC because it allows input from all faculties and is in line with Maastricht University's educational vision. The defined target group consists of people with a professional or personal interest in education in general, and forms of problem-based learning in particular. These will often be teachers, tutors, instructional designers, curriculum coordinators and other educational leaders, but may also include current and future students of master or PhD programs in the educational field or other students interested in PBL.

2.2 Instructional Design

2.2.1 Duration and Workload

The MOOC *Problem-Based Learning: Principles and design. Students at the centre!* is designed to last 9 weeks was designed to have a study load equivalent to 2 ECTS. Figure 1 shows that the first week is a 'pre-week' dedicated to learning more about the structure of the course and forming teams. (The team charter assignment was added later on after pilot study, see Section 3). Subsequently, participants work in groups on authentic problems in a similar way as face-to-face PBL groups, except that they work online and do not have a tutor. Students who actively participate and finish the course are given a Certificate of Participation, but there is no formal exam.

2.2.2 Authentic Problems in Three Tracks

The course is centred around a set of authentic 'problems' organized in three different tracks that are targeted at different types of participants. The first and the last week participants in all tracks work on the same problems, focusing on the learning principles underlying PBL and the application of

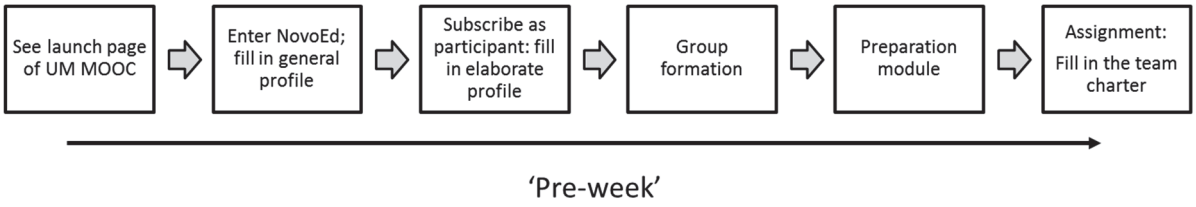

Figure 1: The 'pre-week' in the MOOC *Problem-Based Learning: Principles and design. Students at the centre.*

PBL principles in their own setting. In between they work on track-specific problems (see Figure 2). In the middle part the tracks split up:

- Track 1: The role of the tutor in PBL. This track focuses on the teacher in the role of tutor. This is often the first role that beginning teachers take in a PBL curriculum.
- Track 2: Designing PBL problems and courses. This track focuses on design aspects of PBL, which might be interesting for instructional designers and for more experienced teachers who are taking up the role of PBL problem author or course coordinator.
- Track 3: Assessment and organizational aspects of PBL. This track looks into aspects of PBL at the curriculum level, aligning assessment, implementation and innovation of PBL curricula. It targets educational managers or experienced staff taking up the role of curriculum coordinator.

Each problem is divided over 2 weeks, including a brainstorm phase or pre-discussion, self-study, and a reporting phase or post-discussion. With the problem description some basic resources are given in the form of video clips or public booklets or journal articles. A larger set of references, some free and some licensed, are provided on a Bibliography page.
The project team made an effort to provide examples (in text and video) and learning materials covering the five different domains of Maastricht University: Healthy body, healthy mind, Economics, business, trade and management, International relations, politics and law, Arts, literature and philosophy, and Science and technology.

2.2.3 Working in Small Groups

Small group work is essential to PBL and, therefore, also in this MOOC. In the first 'pre-week' participants are asked to fill out their profile, study the preparation module, and form learning teams (see Figure 1). There are three ways to get into a team:

- Start a new team and invite others to join, e.g. inviting people you already know, or looking for other participants that have a similar backgrounds or interests.
- Join an existing team, looking for an interesting team (based on the team's name, tagline, or profile) or for other interesting participants that you would like to work with (based on individual profiles).
- Wait until you are automatically assigned to a team at the end of the 'pre-week', based on the chosen track and other preferences (only if your profile is filled out).

All members of the team have to take the same track. In principle, the teams stay together during the whole course. However, since anyone can enter and the course is free a large drop-out of up to 95% is to be expected in a MOOC (Devlin 2013)_Therefore, some regrouping is foreseen. Teams that become too small, i.e. do not have enough active members to work effectively, are encouraged to merge with different teams in the same track. As far as possible, the facilitators try to track down inactive teams and to provide suggestions for merges.

<table>
<tr><th>Week 1-2</th><th>Week 3-4-5-6</th><th>Week 7-8</th></tr>
<tr><td rowspan="3">Problem 1:
PBL principles of learning</td><td>Track 1:
The role of the tutor in PBL
(2 problems)</td><td rowspan="3">Problem 8
Application of PBL principles</td></tr>
<tr><td>Track 2:
Designing PBL problems & courses
(2 problems)</td></tr>
<tr><td>Track 3:
Assessment and organizational aspects of PBL (2 problems)</td></tr>
</table>

Figure 2: Three different tracks in the MOOC *Problem-Based Learning: Principles and design. Students at the centre.*

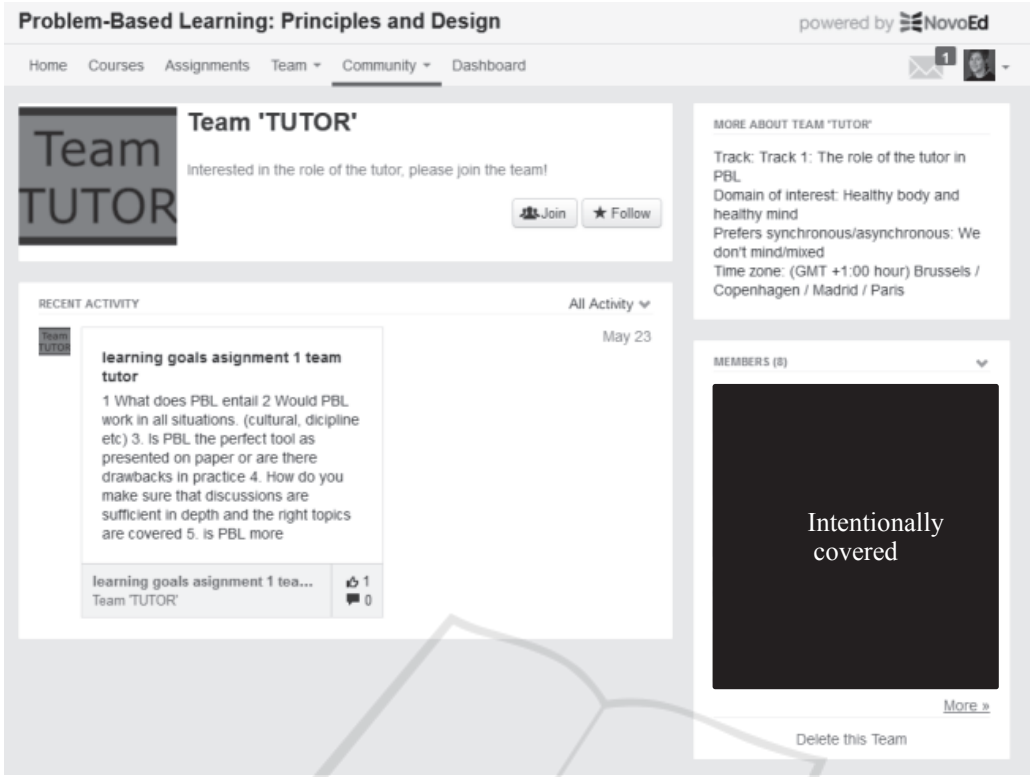

Figure 3: Team space with public profile page and private chat facilities, file exchange and facilities to schedule meetings.

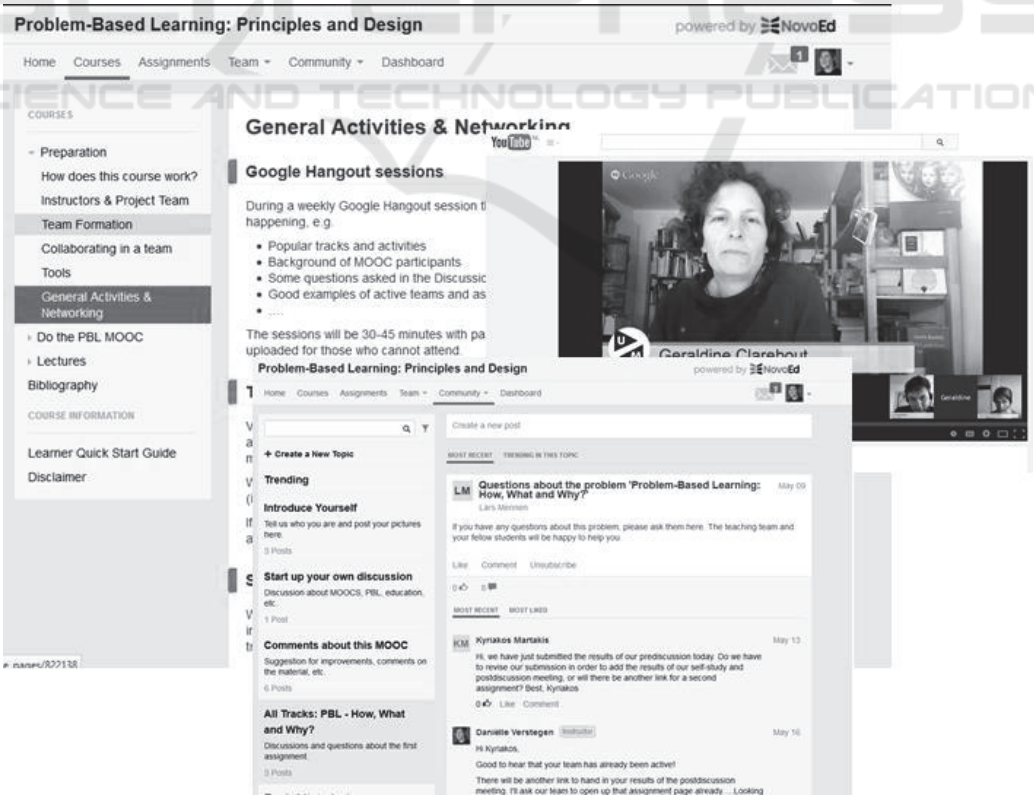

Figure 4: General facilities and networking options.

2.2.4 Peer Review and Evaluation of Team Members

After each problem, i.e. at the end of every second week, participants are asked to peer review the products of three other teams. They are also asked to rate their own contribution to the assignment and to rate the contribution of their team mates on a scale from 'No contribution' to 'Very devoted'. Filling out this evaluation helps us to get insight in who is still active and who is not, and to track down teams that have become very small.

2.2.5 Platform and Tools

The MOOC *Problem-Based Learning: Principles and design. Students at the centre!* has been implemented in NovoED (https://novoed.com/) mainly because this platform explicitly supports small group work.

Each team can avail of a public profile page with chat facilities and a private team space with chat facilities, file exchange, and facilities to schedule meetings (see Figure 3). However, teams can decide themselves how they want to collaborate and communicate, synchronously or asynchronously, using the tools provided in their team space or others, if they prefer.

2.2.6 General Facilities and Activities

The most important part of the MOOC is the small group work on authentic problems, as described above. There are some general activities, however, illustrated in Figure 4:

- A set of mini-lectures about important aspects of PBL which correspond roughly but not exactly to the PBL problems in the different tracks
- General discussion fora accessible to all participants, with some prespecified topics, but also the freedom to start new threads.
- Regular Google Hangouts sessions by the facilitators: sessions of 20-30 minutes where the facilitators react on questions, elaborate specific topics (e.g. related to the tasks of the week), react to main issues in the discussion fora, or give concrete tips for often encountered problems. These sessions are recorded and made available for those who could not attend live.
- Networking opportunities in NovoEd allow participants to search for other participants based on profile information and to contact them, and to follow the public page of other teams.

3 PILOT STUDY

3.1 Method of the Pilot Study

A pilot study was conducted from May 12 2015 to July 12 2015 (9 weeks). Participants were recruited mainly among Maastricht University colleagues using internal media like newsletters and e-mails from faculty management. Some external contacts reacted to an announcement on a mailing list for lunch lectures. A few participants found the pilot course via the NovoEd web address (although it was never announced in newsletters or catalogues). Three facilitators were involved in the pilot study. They responded to questions, and organized three Google Hangouts sessions.

During the pilot study the following data were collected:

- Log data,
- Results of two questionnaires: one after 4 weeks and one after the course had finished,
- Assignments handed in by the team,
- Messages on the general discussion fora,
- Experiences of the facilitators, and
- Verbal feedback from three participants.

The data were analysed by members of the project team involved in the evaluation work package, and subsequently discussed during a plenary meeting with the facilitators and representatives of other work packages. Statistical analyses on log data and questionnaire results are not reported here given the low number of participants at the end of the course.

3.2 Results of the Pilot Study

3.2.1 Participation and Drop-out

As expected there was a large drop-out rate. The fact that the end of the course fell in the start of the summer holidays may have been an extra factor. A total of 104 participants subscribed to the course as students and an extra 23 subscribed as 'auditors' (which in NovoEd gives them access to the course, but not the right to join a group and work on the assignment). Of these students 35 joined one of the 7 teams that were formed. Automatic team formation was not used because only 5 people had not joined a team at the end of the 'pre-week'. They were contacted individually giving a suggestion of the team they could join. At the end of the course 19 participants (18%) were awarded a Certificate of Participation.

3.2.2 Content and Structure of the Course

In general, the PBL tasks seem to have been understandable and suitable. The assignments that were handed in showed that groups were discussing the topics that we wanted them to discuss. In the questionnaires, the discussion fora and the verbal feedback, participants were positive about the assignments and the provided self-study materials.

The different tracks seemed to be appreciated, but the fact that all assignments of all tracks were always visible on the assignment page caused some confusion.

There discussions on the general discussion fora were quite active early in the course. Later on, there was less discussion, presumably because the number of active participants had dropped. Participants interacted with the facilitators and with each other, but discussions were not always placed under the most logical header. They just seemed to continue wherever they had started. Some of the discussion was dedicated to online PBL, maybe because most participants in the pilot study were staff members of Maastricht University and already had ample experience with face-to-face PBL.

Unfortunately, it was very hard to detect which participants were active or inactive, because the platform only provides data at the team level and facilitators have no access to the team space of the teams. There were some other specific issues related to the interface of the NovoED platform, which we will not report in detail here.

3.2.3 Working in Small Groups

Observations and inspection of assignments and discussion fora showed that teams worked in different ways, working on the assignments seriously or at a more superficial level. Some groups put a slightly different focus on what they discussed, e.g. focusing on online PBL. That is not unexpected in a MOOC, were participants can have different backgrounds and interests and, therefore, different learning questions. It may have caused some barriers in the peer review, because the participants could not always follow what another team had done. We also observed that the peer reviews tended to be just an assessment using the sliders, without any comments. The evaluation of team members' contribution was skipped by most participants. When asked, the participants that we spoke to said the task was easily overlooked in the interface and its function was not clear to them.

Another important observation, based on questionnaire data, verbal feedback and questions to the facilitators, was that some groups found it difficult to start up because there is no prescribed way to collaborate or communicate. Some students remarked that they needed more information up front about PBL and the assignments in the course, and about role division and online collaboration in teams. Participants explicitly asked for a clear scheme with all activities and deadlines.

3.3 Changes to the MOOC Design

Based on the results of the pilot study no major changes were made in the content of the course. To reduce confusion the project team decided to provide an explicit time schedule for each track and to open up assignments gradually, so that not all of them are visible at the start. The self-study resources were added to both parts of each assignment to avoid unnecessary navigation.

For the peer review a different format was chosen with open questions in a grid format where participants are asked to briefly describe the strengths and weaknesses, to explain what was not clear and to give some suggestions or new ideas. The explanation of peer review and evaluation of team members' contribution was improved.

In the 'pre-week' an extra assignment was added. The newly formed teams are asked to fill out and hand in a Team Charter, asking them to divide roles (who will lead, who will plan, who will hand in assignments) and rules for collaboration. In the team charter the teams also describe how they will communicate (synchronously or asynchronously) and which tools they will use. Some open questions at the end ask them to discuss how they will deal with unequal participation and lurkers, unwanted behaviour, etc. The text of the team charter assignment also gives more elaborate information about the PBL-assignments in the course and about what they will be expected to do in the course, giving a few examples of how they might want to work, rather than being prescriptive.

To stimulate and structure the discussions on the general fora the project team decided to reduce the number of fora and to stimulate participants to make new threads with clear names themselves. The facilitators should try to keep an eye on the discussions and ask participants to move to a different forum if that seems more suitable.

4 THE FIRST REAL MOOC: FIRST IMPRESSIONS

The MOOC *Problem-Based Learning: Principles and design. Students at the centre!* started on October 5 2015 and lasted until December 12. The execution of the MOOC was advertised using the NovoED catalogue and newsletter, Maastricht University communication channels including newsletters and alumni networks, a press release, and social media like Twitter and LinkedIn, using both personal contacts from project team members and joining groups related to MOOCs. There are four facilitators in the course (see Figure 5).

First impressions are reported here since the analysis of data is not completed yet. The MOOC started with 2989 subscribers: 2653 students and 336 auditors. Just over a quarter (26%) filled in their profiles and became part one of the 111 teams. There is an overrepresentation of teams following Track 2. Tracks 1 and 3 are less popular. The Google Maps in the forum 'Introduce yourself' shows that they are from all over the world with concentrations in Europe and South America (see Figure 6).

The majority of teams was formed by the participants themselves (98 teams) and 13 teams were formed automatically at the end of the 'pre-week' from participants who had filled in their profile but not joined a team yet. Some of the self-formed teams are region-based, or even formed by colleagues from the same institute. Others formed around a certain area of interest, such as professional education or language teaching. These interests also come back on the heavily used general discussion fora where hefty discussions take place about a variation of topics, ranging from 'what does a good tutor do?' to 'can I use PBL for mathematics, primary school children, disadvantaged students, etc.'

49 of the 111 teams finished the course (i.e. handed in the last assignment) and 264 participants were received a certificate of participation. It became clear very quickly that self-formed teams function better than automatically formed teams. Most of the 13 automatically formed teams never even handed in the first assignment. Especially at the beginning of the MOOC contributions to the discussion for a showed that some people found it difficult to join a team.

Inspection of the assignments shows that the quality of the assignment varies, but that, in general, the teams have followed a PBL like process (brainstorming, formulating learning questions, reporting and discussing results). The project team members who were responsible for writing the problems were surprised by the quality of a large part of the assignments.

Discussions on the fora and inspection of the assignments also show that teams collaborated and communicated in very different ways. For some teams it took time to find a good way to collaborate, and some teams clearly struggled. Other teams seemed to have no trouble to establish a way of working and showed great creativity in the tools and methods they used. The project team has observed a number of teams in more detail, following the interaction between team members in their team space by joining their team as an observer (after informed consent). The results are currently being analyzed.

Figure 5: Flyer page of *Problem-Based Learning: Principles and design. Students at the centre.*

Figure 6: Participants of *Problem-Based Learning: Principles and design. Students at the centre.*

5 CONCLUSIONS

Designing and running the MOOC *Problem-Based Learning: Principles and design. Students at the centre!* has shown that it is possible to apply some aspects of PBL in a MOOC: constructive and contextual learning centred around authentic problems, and collaborative learning by asking participants to work on these problems in small teams. For a MOOC this is an innovative design, and distinctly different from the usual designs for xMOOCs and cMOOCs.

Whether this MOOC can be called PBL remains questionable; it differs from more traditional forms in some important aspects, such as the absence of a tutor and very limited amount of feedback and support.

Online collaboration in virtual teams remains a challenge, and requires dedicated support. A large drop-out is to be expected, and not all teams will succeed. More research into factors determining team success or failure is required.

ACKNOWLEDGEMENTS

The authors would like to thank the entire project team of the MOOC project.

REFERENCES

Ahn, J., Butler, B.S., Alam, A. & Webster, S.A. 2013. Learner participation and engagement in open online courses: insights from the Peer 2 Peer University. *MERLOT Journal of Online Learning and Teaching,* vol. 9, no. 2. Available from http://jolt.merlot.org/vol9no2/ahn_0613.htm.

Barrows, H.S. 2002. Is it truly possible to have such a thing as dPBL? *Distance Education,* vol. 23, no. 1, pp. 119-122.

Barrows, H. S. & Tamblyn, R. M. 1980. *Problem-based learning: an approach to medical education.* Springer: New York.

Bussemaker, J. 2013. *Open en online hoger onderwijs* (Brief aan de Tweede Kamer der Staten-Generaal, Referentie 581269) [Open and online higher education (Letter to the parliament, Reference 581269)]. Ministerie van Onderwijs, Cultuur en Wetenschap: Den Haag, The Netherlands (In Dutch).

Devlin, D. 2013. *MOOCs and the Myths of Dropout Rates and Certification*. Available from: http://www.huffingtonpost.com/dr-keith-devlin/moocs-and-the-myths-of-dr_b_2785808.html (3-2-2013).

Dolmans, D.H.J.M., de Grave , W. , Wolfhagen, I.H.A.P. & van der Vleuten, C.P.M. 2005. Problem-based learning: future challenges for educational practice and research. *Medical Education,* vol. 39, pp. 732 – 41.

Hollands, F.M, & Tirthali, D. 2014. *MOOCs: Expectations and reality. Full report.* Columbia University, Teachers College, Center for Benefit-Cost Studies of Education: New York.

Holton, D. 2012. *What's the "problem" with MOOCs*. Available from http://edtechdev.wordpress.com/2012/05/04/whats-the-problem-with-moocs/ (4-5-2012).

Mackness, J., Waite, M., Roberts, G., & Lovegrove, E. 2013. Learning in small, task-oriented connectivist MOOC: Pedagogical issues and implications for higher education. *The International Review of Research in Open and Distance Learning,* vol. 14, no. 4. Available from http://www.irrodl.org/index.php/irrodl/article/view/1455/2531.

McAndrews, P. & Scanlon, E. 2013. Open Learning at a Distance: Lessons for Struggling MOOCs, *Science,* vol. 342, pp. 1450-1451.

Morrison, D. 2013. *The Ultimate Student Guide to xMOOCs and cMOOCs*. Available from http://moocnewsandreviews.com/ultimate-guide-to-xmoocs-and-cmoocso/ (22-4-2013).

Moust, J., Bouhuijs, P. & Schmidt, H. 2014. *Introduction to Problem-Based Learning: A Guide for Students.* Noordhoff Uitgevers B.V.: Groningen, The Netherlands.

Waldrom, M.M. 2013. Campus 2.0: Massive open online courses are transforming higher education – and providing fodder for scientific research. *Nature,* vol. 495, pp.160-165.

Yuan, L. & Powell, S. 2013. *MOOCs and Open Education: Implications for Higher Education* (A white paper). University of Bolton: CETIS: Bolton, UK. Available from http://publications.cetis.ac.uk/

Worldwide Universities Network. 2013. *Annual Report 2012-2013: Tackling Global Challenges through International Collaboration.* Available from: http://www.wun.ac.uk/about.