CORE
Metadata, citation and similar papers at core.ac.uk
Provided by University of Southern Queensland ePrints

AAEE2017 CONFERENCE
Manly, Sydney, Australia

Running an Open MOOC on Learning in Laboratories

Alexander A. Kist; Hannah Campos Remon; Lindy Orwin; Andrew Maxwell; Ananda Maiti; Victoria Terry and Peter Albion
University of Southern Queensland, Toowoomba, Australia
Corresponding Author Email: kist@ieee.org

CONTEXT Teaching in laboratories plays an integral role in education. This includes both proximal as well as remote laboratories. In many instances, learning activities are designed around equipment and traditional laboratory activities. Pedagogical aspects and instructional design are often not considered or are an afterthought.

PURPOSE The aim of this project was to help to address this gap by designing, implementing and facilitating an open online course on the pedagogy of using laboratory experiences in the curriculum.

APPROACH The MOOC for Enhancing Laboratory Learning Outcomes (MELLO) has been designed to assist educators at all levels, from schools to universities, to improve the quality of laboratory experiences in STEM (Science, Technology, Engineering, and Mathematics) education. Experienced educators seeking to review and revise current practices or beginning educators were all welcome to participate. Based on learning theory and research literature, online course has been developed that covers constructive alignment of practical activities with the wider curriculum, learning objectives, pedagogical approaches to laboratory learning, laboratory modalities and session planning.

RESULTS 120 participants from Australia and around the world took part in the course. While the participants did not work on their own laboratory activity throughout the courses (as envisaged when designing the course), participants who actively took part in the course were positive about the value of the course.

CONCLUSIONS The MOOC has been capable of supporting a large number of participants including university educators around the world who use laboratory experiences and will continue to do so through future iterations of the course. Moving forward, there is scope to adapt the pedagogical approach of the course to cater for the way the participants have engaged with the material.

KEYWORDS laboratory teaching, practical learning activities, MOOC

This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/

Introduction

When designing learning activities, one of the key focus questions is: What do we want the students to be able to do when they have completed the activities? In the context of practice-based disciplines such as Engineering and Sciences, this often includes practical tasks. Such skills are traditionally taught in laboratory classes and these are often favourites of students as they provide tangible ways to apply theoretical concepts.

Technological developments in the last two decades have enabled new approaches for teaching through laboratories These include remote laboratories (Maiti, Maxwell, & Kist, 2014), virtual laboratories (Nedic, Machotka, & Nafalski, 2003) as well as augmented reality in labs (Andujar, Mejías, & Marquez, 2011). These allow access to hardware or virtual experiments remotely via the Internet but come with a range of pedagogical issues which need to be tackled for optimal implementation.

Learning and teaching is being widely addressed for academic classes, through learning and teaching support units, for example. There is also a strong focus on articulated learning outcomes by Australian Higher Education Standards Framework (Birmingham, 2015) and professional accreditation bodies such as Engineers Australia. However, this focus often does not translate to pedagogical approaches to teaching in laboratories.

Anecdotal evidence suggests that many laboratory activities are not outcomes of critical evaluation and course design; they are often products of tradition, availability of equipment, personal exposure and preferences of academics involved.

An OLT project on adaptive learning guides (Lowe, Murray, Lindsay, & Bharathy, 2014) has also identified this shortfall, both in the literature review of the project report as well as the evaluators comments. Appendix C p. 3-4 states that "...there has been less attention to the pedagogic issues involved in providing skeleton lesson plans. This is a potentially interesting direction for future work in the area."

The Massive Open Online Course (MOOC) for Enhancing Laboratory Learning Outcomes (MELLO), disused in this paper is an attempt to address this gap. The remainder of the paper briefly introduces the underlying educational framework followed by a section that outlines the course design. Sections on data collection, findings and observations conclude the paper.

Educational Framework

The content that is presented in MELLO is based on key literature in the field. Main sources that have informed the content development include fundamental objectives of Engineering instructional laboratories (Feisel & Rosa, 2005) and generic aims for traditional Science laboratory learning (Johnstone & Al-Shuaili, 2001). These are linked to learning activities in laboratories through the principle of constructive alignment (Biggs & Tang, 2007). For example, White's (1996) description of how "laboratory" learning can be conceived of as an instance in which the learner experiences learning "episodes¨ has been explored as this places a greater focus on learning objectives, activities and outcomes instead of equipment, as is often the case in discussions of laboratory tasks.

Laboratories can be classified as expository, inquiry, discovery, and problem-based (Johnstone & Al-Shuaili, 2001). This approach helps to better understand condition for learning, laboratories present and helps to unpack associated aims, outcomes, approaches and procedures. Generally speaking, teachers can support the development of appropriate learner behaviours by designing lessons and scaffolding learning according to the conditions for learning that are appropriate to the lab type (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989, pp. 53-64).

Course Design

This course has taken an educational rather than a technical focus on the design of labs. It therefore covers a set of key educational issues for the effective design of labs, including:

- Constructive alignment between labs and other aspects of curriculum
- Design and selection of achievable learning objectives
- Selection and implementation of an appropriate pedagogical approach to labs – matched to the learning objectives that have been set (for example, expository, discovery or problem-based)
- Selection of appropriate lab modality (e.g. face to face, versus remote, versus simulated)
- Planning and preparing lab sessions for enhanced learning

Participants in the course have a degree of choice over how they participate. At the most basic level, the course provides a series of lectures, videos and resources as stimuli for participants to begin considering how labs should be designed in order to be educationally effective. These materials form the core of the course upon which other optional activities can be built. In addition to these materials, a number of planning and design activities are suggested for participants to undertake individually in order to progress their own instructional design knowledge and experience. As such, the course has an organizing and critically reflective function not available to teachers simply searching for available information about labs.

Course Learning Outcomes

The main course outcomes can be summarised as follows: By the end of the course, participants will be able to

- contrast how laboratory activities are used in different disciplines and identify parallels to your own laboratory learning activities,
- draw a map of how the learning activities in your lab are aligned,
- evaluate different types of laboratories, learning opportunities they present and apply the insights to your context,
- develop activity guides and lesson plans based on sound pedagogical principles.

Modes of Participation

MOOCs come with various degrees of social interaction and levels of commitment by participants. To cater for a broad spectrum, MELLO has supported two modes of participation, a connectivist MOOC (cMOOC) focusing on a mix of self-directed and social learning; and an xMOOC that provides open access to learning materials. The cMOOC has used an Action Learning approach based on the model developed by Revans (2011) that uses an iterative process of “Explore - Plan - Act - Reflect”. In contrast, the xMOOC supports self-paced participation with access to the content created for the “Explore” component of the cMOOC and discussion forums.

The x-mode is intended to engage individuals who want quick access to the content, structure and activities of the course, but are unwilling or unable to commit to regular meetings, sharing, and the timelines of the Action Learning Cycle. The benefit of the course in the xMOOC mode is that it helps participants to access key materials and organize and think about the materials and their implications in a way that conducting their own search of the literature would not do (or would take much more time to do). In this view, the course

provides structure to the key theory, research and examples in the laboratory learning field, thus improving access to the field for participants.

Platform Used for the Course

There are a number of large open learning platforms available, such as Coursera, Ed-X, Udacity, Canvas Network and Open Learning. Given that the project operated on a small budged and that home institution is not affiliated with any of the larger providers, finding a suitable platform proved to be a challenge. The other difficulty was around requirements of copyright and content ownership. These issues caused some significant delays and ultimately required the rescheduling of the course start.

The constraints included a platform that allows fee access to the course. Ultimately an agreement was reached that satisfied the requirement of the funding body, the institution's legal requirements and the need to access to appropriate facilities to deliver the course. In the end, operational factors outweighed considerations for educational features. OpenLearning was used as a platform to offer MELLO, which generally worked well for the xMOOC component of the course.

Course Structure

Typical modules in the course consist of web-based, multimedia & text-based study materials. Brief expert videos and webinars provide stimulus material about key concepts. Virtual tours provide a window into labs in use. These components are combined with activities, contributions by participants and further reading. The main modules are:

Module 1 - Developing laboratory classes for the digital age

Module 2 – Developing the aims, objectives and alignment of laboratory classes

Module 3 - Types of labs and the conditions for learning they present

Module 4 – Structuring and Supporting Learning in Laboratory Classes

Module 5 - Modern Laboratory Learning Environments

Module 6 - Bringing it all together - developing activity guides and lesson plans

Data Collection

In order to assess the value, relevance and significance of the course, data was collected from participants in three ways. As a part of the course activities (subject to explicit consent) students in the course completed both entry and exit surveys in order to both analyse their own needs and goals, and to gather information about their reasons for participation, their expectations and perceptions of the course. This data helps in the interpretation of discussion data that was collected during the course from students engaged in course activities within the open learning platform. This data gives insights into how students were responding to specific issues within the course, and therefore whether the course was meeting its aims.

Observations

Whilst 120 students participated in the course, there was a smaller group who actively contributed to discussions. As is common in MOOC courses, significant attrition was apparent as the course progressed. It should be noted that such attrition is not necessarily indicative of the value or effectiveness of the course, because it is not known what the goals or expectations of departing students were if they did not complete an entry survey. For example, if their goal was to access specific information for their own needs, the course satisfying this goal may be the reason for their early departure. Such an instance would mean the course was successful rather than the opposite.

Participation Over Time

Figure 1 shows student comments (in discussion topics) over time. The graph suggests that the early interest in the course was high and that this was supported by the high level of activity within the cohort.

That is, it is more interesting and rewarding to engage in discussion when there are many others also doing so. It should be noted that not all students joined the course at the same time, which is why the spread of comments does not coincide with the ten-week period around which the course is designed.

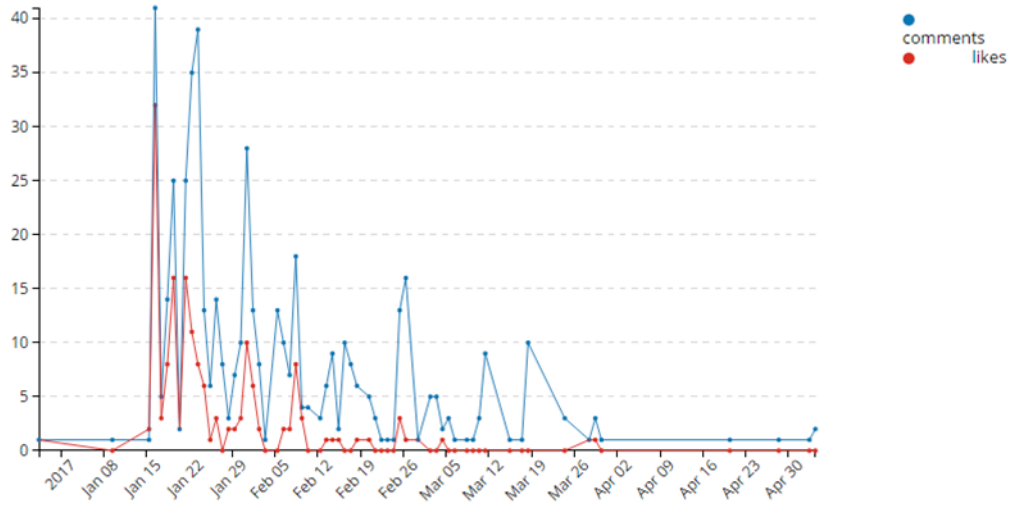

Figure 1 Figure 1 - Number of participant comments and likes over time

Participants' Motivation

First, it is necessary to note some findings from the entry and exit surveys concerning participants´ reasons for participation. In total, 24 participants completed the voluntary entry survey, and seven completed the exit survey. Whilst this appears to be a high level of attrition, the research literature shows this to be normal in MOOCs (e.g., Gütl, Rizzardini, Chang, & Morales, 2014).

The entry survey asked participants their reasons for taking part in the course. Of the 24 responding participants, it is noteworthy that only five of these cited specific pedagogical goals and two specific curricular goals. Their specific comments are as follows:

Specific pedagogical goals:

- I work in educational development in STEM. I would like to learn more about lab teaching in a global perspective and am curious to see how a MOOC on lab teaching can be organized.
- I am working to modernize our labs and want a fresh perspective of how labs are offered elsewhere and get insight into the advances in delivering labs.
- Working as a young assistant professor in a technical university implies, in general, teaching applications for different disciplines. In my case, most of these applications consist in practical lessons conducted inside lab sessions. For this reason, I continuously try to develop my teaching skills and the way I organize my laboratory classes in order to improve the learning activities I conduct during these classes and I

am confident that this course will help me to make a step forward in achieving this objective.

- We are in the process of revamping a number of our lab courses and it seemed like this course would give me food for thought.
- How to design a pedagogical efficient lab activity.

Specific curricular goals:

- Because I am working on the development of remote laboratories in the electronics field.
- I am looking for ways to improve the practical part of the courses I teach.

Only some of these goals relate to the development or improvement of specific laboratory activities. The remainder of the participants´ comments concerning their reasons for taking part were seen to be either general pedagogical goals or general learning goals (10 and 7 instances respectively). For instance, some participants cited “curiosity”, wanting to improve their teaching in a general way or “to get the best for my students.” Whilst these are all valid aims, they do not necessarily coincide with an ability among participants to undertake the specific lab design activities that were suggested in the course. Similarly, comments about expectations about and desired outcomes of the course show that many participants had not formed a clear idea of what they would get from the course. This may explain why no participants showcased a revised lab activity at the end of the course.

Notwithstanding these findings, the other comments from the entry and exit surveys are uniformly positive about participants´ value for the course. Of the seven participants who completed the exit survey, three agreed and four strongly agreed that the course had helped them to think effectively about what laboratory teaching entails, and four agreed and three strongly agreed the course had helped them to think about what laboratory learning means for their students.

Action Learning Participation

Of the one hundred and twenty participants in the MOOC, only four (3.3%) registered interest in participating in the Action Learning mode. Of these only two completed that process by forming a learning set and participating in the online meetings and creating a project. Both responded to the exit survey with one agreeing and the other strongly agreeing that the Action Learning cycles were successful in engaging them in this MOOC.

There were a number of challenges when preparing to conduct Action Learning in the context of a MOOC. Firstly, Action Learning is not a commonly used professional learning strategy in MOOCs. No evidence of conducting a MOOC using a formal Action Learning process as the pedagogical approach was found in the literature prior to this attempt. The novelty and unfamiliarity of the approach may have impacted willingness to participate in this mode.

Secondly, the technical capability of this and other MOOC platforms limits the ability for participants to find other participants in compatible time zones to form learning sets. The lack of a suitable tool for self-matching meant that Action Learners had to register and then wait to be matched with potential Learning Set members using tools outside the MOOC platform. This challenge was compounded by the staggered starting dates of many participants. One participant who requested to engage in an Action Learning mode joined the course four weeks after the beginning of the program and as a result, there was no one to match them with. Another potential Action Learner never responded to the internal messages in the system to complete the matching process.

A dedicated tool for matching participants to form Action Learning Sets in MOOCs would solve this problem. The features would need to include the attributes of the individuals that

would allow matching. This could include time zone, days and times available for Learning Set meetings, languages spoken, email address, and platform for web-conferencing.

Thirdly, Action Learning Sets, the small groups who meet periodically through the course, usually meet synchronously. In online programs, this means they need to use tools such as text chat, audio chat, virtual worlds or web-conferencing. This adds a requirement for a level technical expertise not required in the self-paced mode which simply involves clicking on links on web pages, viewing videos and typing comments. This may have been another barrier to selecting Action Learning as a mode of engagement with the MOOC.

Relevant Pedagogies for Laboratory Learning

Concerning whether the MOOC had given them strategies for identifying appropriate pedagogies for use in their lab and whether it gave them the chance to share and explore explicit strategies for improving lab learning, and how the strategies could be introduced to their teaching, the results were more equivocal:

The MOOC gave me strategies for identifying appropriate pedagogies for use in my lab					
Neutral	2	Agree	**1**	Strongly agree	3
The MOOC gave me the chance to share and explore explicit strategies for improving laboratory learning in my students					
Neutral	2	Agree	**4**	Strongly agree	1
I can see how at least some of the strategies can be introduced to my teaching					
Neutral	3	Agree	**1**	Strongly agree	3

Table 1 - Exit survey responses about specific pedagogical strategies

Here, the neutral responses may relate to participants´ lack of a specific lab activity to relate the teaching development to.

As was seen above, discussion in the course was higher in volume in the early stages of participation, and facilitators participated in this discussion to try to promote in-depth discussion of the activity questions that were provided. However, although contribution to discussion was frequent and at times thoughtful and insightful, especially during the first two modules, participants did not often comment on one topic more than once, thereby limiting the depth of discussion. Where the facilitator participated in discussion posts with feedback or requests for more information, this was often not responded to, or a superficial level of thought was given to the prompt

The course (especially the activity prompts that were provided) intended that participants would reach a greater degree of discussion and reflection on the issues being discussed. However, this degree of discussion may not be achievable in asynchronous forums, and may better lend itself to synchronous sessions, such as the action learning groups. This may be tested in future iterations of the course, with greater numbers of participants actively contributing in each access mode.

A number of strategies are available that may assist with this. First, recruitment of participants into the course should better emphasise that the course is most effective for participants who have a specific laboratory learning experience in mind or that is relevant to their context to be used as an example or a tool for thinking about the issues with. Without this, some of the fundamental problems highlighted throughout the course, such as a tendency to design for students to complete a task instead of designing for students to learn something specific, do not become clear to participants. Second, with ongoing and increasing participation in the course, a community of inquiry may be built in which existing participants may continue to take part in discussion around core issues. This kind of critical mass would allow for the improvement of both volume and depth of discussion.

Conclusions

The course has supported educators form a range of disciplines including Engineering, Sciences, Health Sciences, ICT and Teacher Education. Participants included university educators as well as Secondary School Science teachers. This led to more diverse interactions on laboratory experiences in learning and teaching. The project has developed resources that will remain available. It has enabled systematic and broad opportunistic adoption of best practices in the use of laboratory experiences in learning and teaching at universities and in schools. While most participants have not engaged with the courses in the way it was originally designed, the participants were very positive about the course and the content.

References

Andujar, J. M., Mejías, A., & Marquez, M. A. (2011). Augmented reality for the improvement of remote laboratories: an augmented remote laboratory. *IEEE transactions on education, 54*(3), 492-500.

Biggs, J., & Tang, C. (2007). Teaching for quality learning at university (Society for research into higher education).

Birmingham, S. (2015). Higher Education Standards Framework (Threshold Standards) 2015. [Canberra]: Commonwealth of Australia.

Feisel, L. D., & Rosa, A. J. (2005). The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education, 94*(1), 121-130.

Gütl, C., Rizzardini, R. H., Chang, V., & Morales, M. (2014). Attrition in MOOC: Lessons Learned from Drop-Out Students. In *Learning Technology for Education in Cloud. MOOC and Big Data: Third International Workshop, LTEC 2014, Santiago, Chile, September 2-5, 2014. Proceedings* (pp. 37-48).

Johnstone, A., & Al-Shuaili, A. (2001). Learning in the laboratory; some thoughts from the literature. *University Chemistry Education, 5*(2), 42-51.

Lowe, D., Murray, S., Lindsay, E., & Bharathy, G. (2014). *Enhancing remote laboratory learning outcomes through lesson plan integration within a learning management system framework: Final report 2014*. Retrieved from Sydney, Australia: http://www.olt.gov.au/project-enhancing-remote-laboratory-learning-outcomes-through-lesson-plan-integration-within-lms-fra

Maiti, A., Maxwell, A. D., & Kist, A. A. (2014). Features, Trends and Characteristics of Remote Access Laboratory Management Systems. *iJOE, 10*(2), 30-37.

Nedic, Z., Machotka, J., & Nafalski, A. (2003). *Remote laboratories versus virtual and real laboratories* (Vol. 1): IEEE.

Revans, R. (2011). *ABC of action learning*: Gower Publishing, Ltd.

Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer-supported intentional learning environments. *Journal of educational computing research, 5*(1), 51-68.

White, R. T. (1996). The link between the laboratory and learning. *International Journal of Science Education, 18*(7), 761-774.

Acknowledgements

Support for this project has been provided by the Australian Government Department of Education and Training. The views expressed in this paper do not necessarily reflect the views of the Australian Government Department of Education and Training. The authors would like to thank the Global Online Laboratory Consortium (GOLC) for the support and the various contributors and participants for sharing their time and insights.