Research and Development in Higher Education: Curriculum Transformation

Volume 40

Refereed papers from the
40th HERDSA Annual International Conference

27-30 June 2017
International Convention Center Sydney, Australia


Published 2017 by the
Higher Education Research and Development Society of Australasia, Inc
PO Box 6106, Hammondville, NSW 2214, Australia
www.herdsa.org.au

ISSN 1441 001X
ISBN 978-0-9945546-6-6

This research paper was reviewed using a double blind peer review process that meets DIISR requirements. Two reviewers were appointed on the basis of their independence and they reviewed the full paper devoid of the authors’ names and institutions in order to ensure objectivity and anonymity. Papers were reviewed according to specified criteria, including relevance to the conference theme and audience, soundness of the research methods and critical analysis, originality and contribution to scholarship, and clear and coherent presentation of the argument. Following review and acceptance, this full paper was presented at the international conference.

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Universities are now tasked with competing in a global education market. Consequently there are considerable creative, pedagogical, and capacity building challenges for institutions, many of which are related to curriculum transformation. Curriculum transformation is a deliberate process of marked change in learning and teaching that impacts the construction of effective learning environments. In this paper we discuss curriculum transformation at an Australian university, where challenging opportunities for innovation were recognised and taken up, resulting in new learning pathways for students and the organisation. The design of two massive open online courses (MOOCs) is presented as a triggering event for change. MOOC evaluation findings confirm the need to establish quality parameters for curriculum innovation projects; the contribution of personal and organisational learning to the transformation process; the need to select the delivery platform early in the project development stage; and issues of designing for a culturally and educationally diverse student body with widely divergent motivations and capabilities. The evaluation was conducted using mixed methods, and the Phillips et al. elearning evaluation lifecycle applied as a tool for mapping stages of evaluation against the design process. The potential for new conceptual models for learning as a result of MOOC experiments is offered as an area for future research.

**Keywords:** evaluation, curriculum transformation, MOOCs, pathways

**The context for curriculum change**

“We must take the current when it serves, or lose our ventures.”

(Shakespeare, *Julius Caesar*, Act 4, scene 3)

To remain relevant in an increasingly competitive global education market, universities must situate themselves to respond rapidly to change (Coaldrake & Stedman, 2013). The context for learning is being disrupted at every level by social, political and technological change, diverse market driven economies (Zajda & Rust, 2016), and environmental pressures. Universities that have long prided themselves on their traditions must now radically adapt and transform, or risk being by-passed as redundant educational institutions (Arvanitakis & Hornsby, 2016). Challenges can be used as opportunities for innovation and consideration of new curricula and new learning environments. The higher education sector is increasingly called upon to reinvent their traditional structures, processes, curricula and pedagogic practices (Bridgstock,
While there is debate about the extent of the contribution of MOOCs as catalysts for change (Joksimovic, et al., 2015), there is evidence that MOOCs do act as disruptive agents, transforming educational policy and practice, and boosting innovation in universities (Ossiannilsson, Altinay & Altinay, 2016). This paper is a discussion on findings from the evaluation of two MOOCs in robotics at an Australian university. It contributes to the body of knowledge around MOOCs as catalysts for change and adds to the literature on MOOC curriculum design and transformation from an Australian perspective. We argue that the design and production of the first two MOOCs at our institution required significant innovation to enable curriculum transformation. This contributed to ensuing ventures in online learning, and the opening up of learning pathways for students. Curriculum in this context is conceptualised in broad terms, and concerned with the process of constructing effective learning environments. Learning environments are regarded as relational spaces that shape and are shaped by the processes and players within the context; and innovation is defined as creativity at the organisational and systems level.

A curriculum design and transformation perspective

By way of definition, our perspective on curriculum design and transformation is holistic. It goes beyond a concept of curriculum as the course syllabus. We draw on the work of Fraser and Bosanquet (2006) who distilled four conceptions of curriculum from a phenomenographic study of academics’ beliefs about curriculum. The conceptions were: “(A): The structure and content of a unit (subject); (B): The structure and content of a program of study; (C): The students’ experience of learning; and (D): A dynamic and interactive process of teaching and learning” (Fraser & Bosanquet, 2005, p. 272).

In our discussion, curriculum transformation is conceptualised in the main as category (D), but also encompasses the structure and content of courses and programs, the student experience, the related learning and teaching processes, and the context for learning. This holistic view is concerned with the creation and transformation of learning environments, and the “practice and context of the curriculum” (Fraser & Bosanquet, 2006, p.278). Learning environments are relational, and “person and environment are mutually entailed” (Goodyear & Carvalho, 2013, p.50). Effective learning environments facilitate learning (Phillips, McNaught & Kennedy, 2012), and they are virtual and/or physical spaces.

The potential of MOOCs to open up new educational pathways

MOOCs have been on the higher education landscape for almost a decade. The first MOOC appeared in 2008, with George Siemens’ experimentation with a loosely organised, connectivist inspired MOOC (cMOOC). This was followed by more traditionally structured MOOCs (xMOOCs) (Gasevic, et al., 2015; Ross, et al., 2014). Ross et al. (2014) argue that MOOCs now take many pedagogical forms and that classification into either connectivist or traditional MOOCs oversimplifies the debate and demonstrates the need for greater critique in this domain.

Early MOOC developments were driven in part by the MIT OpenCourseWare initiative in 1999 and the Open Educational Resources (OER) movement (Atkins, et al., 2007). The OER movement argued for wider provision and access to high quality educational resources.
Joksimovic, et al. (2015) maintain that the aim of democratising educational provision has not yet eventuated – either driven by the OER movement or the proliferation of massive open online courses. This view is supported by a large-scale study conducted by Stich and Reeves (2017), who examined student participation in MOOCs between 2008 to 2015, and the role of MOOCs in promoting access to higher education. They argue that those learners who succeed in completing assessments and gaining certification in MOOCs already have the study skills and habits that lead to success. Hence MOOCs may not yet be fulfilling their promise of democratising and opening up educational opportunities and pathways for all.

In parallel with moves to improve access to higher education, and adopt new pedagogical approaches, supporting digital technologies have rapidly developed. Students and teachers now have the tools to more easily create, share and host rich and self-published media (De Freitas, et al., 2015). Open source and commercial learning management platforms have developed, capable of supporting massive numbers of student enrolments in a single course (e.g. edX, FutureLearn, Coursera, Udacity). In a highly networked and globalised system, there is now potential for online learning models to shift from ‘individualised acquisition of content and skills’, to systems that enable networks of ‘people, technologies, knowledge and ideas’ (Mason & Rennie, p.6). However, Margaryan, Bianco, and Littlejohn’s (2015) assessment of MOOC quality is that while the content and production values of MOOCs has been high, there is room for improvement in the educational design of some courses before this networking potential is fulfilled.

The MOOC phenomenon has also prompted consideration of alternative economic models (Ossiannilsson et al., 2016; Prpic et al. 2015). For example, Ossiannilsson et al.’s, (2016) research confirms MOOCs as new business models for triggering innovation in higher education. The use and reuse of MOOC courses as ‘resources’, just as textbooks and journals are used in traditional higher education, may result in the reuse of MOOCs as a natural part of university approaches to learning. This approach has been trialed at our university, for example: through a deliberate process of curriculum transformation a flipped classroom model (Brame, 2013) was implemented in an undergraduate robotics unit, with content (videos and animations) from the open robotics MOOCs reused in the award course.

The MOOC project: Taking the current when it serves

Within the context of this changing digital and educational landscape at a global level, plans for a MOOC project at the local level at our university were discussed. The project originated in 2013 when the idea of promoting robotics to a global audience, and the wider sharing of educational resources along OER principles, was suggested by the lead educator. The goal was twofold: firstly, to provide an open course based on the current third-year offering from the engineering department; and secondly, establish a database of resources and mini tutorials similar to the Khan Academy (khanacademy.org): a ‘robot academy’. Other institutional goals around showcasing university research strengths and the university brand emerged subsequently. Funding was approved for the first goal, and the curriculum transformation process began, turning an introductory, thirteen-week, third-year undergraduate unit into two, shorter six-week MOOCs. Following needs analysis, design, production, testing, and formative evaluation, the courses were implemented in early 2015. Summative evaluation followed implementation. The second goal of the ‘robot academy’ was, however, put on hold.

The university saw an opportunity to be bold and innovative: it ‘took the current as it served’. As with all innovation projects, there were risks. The university had a strong tradition of
servicing on-campus students, rather than online and distance students, and the MOOCs were the first courses of their kind at the university. Consequently, systems for implementation and delivery of fully online courses at such the scale did not exist; and solutions for teaching, assessing and supporting the expected large diverse student cohort were limited. Neither the business models nor the necessary supporting technologies were in place when curriculum planning started. To create the learning platform, the university chose to work with an open source start-up company, not an established MOOC platform provider. Additionally, at the time, the literature and empirical evidence on MOOCs was nascent, and typically derived from North American experience (confirmed by Gasevic, et al., 2015). Significant reports such as that produced by Siemens, Gasevic, and Dawson (2015) were not available. Even now research into MOOCs is still dominated by North American research (Gasevic, et al., 2015), hence the need for more research such as this into the Australian experience.

**Methodology**

![Figure 1: Stages of evaluation mapped against MOOC project stages. Evaluation moved from baseline analysis through 4 stages of formative evaluation, to summative project evaluation (stage 5), and evaluation as a research process (stage 6). Source: Philip & Greener (2016, p.10), based on the Phillips et al. (2012) elearning evaluation lifecycle.](image)

The goal of the MOOC evaluation was to determine the efficacy of the MOOC environment in context, and the implications for the institution of designing, developing and implementing online courses at a massive scale. A mixed methods approach was employed for data gathering and analysis. Data collection methods included six surveys (pre-, mid- and post-course), two focus groups with production and teaching support staff, discussion forum postings, email feedback from students, weekly teaching assistant and production staff logs,
analytics from the MOOC platform, Google and YouTube analytics, an additional external course website with computer programming resources, and marketing statistics (see also Philip & Greener, 2016, pp. 33-34). In terms of analysis, descriptive statistical methods were used to synthesise the quantitative data, and constant comparative methods (Charmaz, 2011) for the qualitative data. University ethics approval was sought and granted for the research.

We mapped stages of formative and summative evaluation against stages of the project, adapting the Phillips, McNaught, and Kennedy (2012) elearning evaluation lifecycle model (see Figure 1). Phillips et al. argue that investigation into elearning contexts includes a mixture of evaluation and research, and they identify five stages where evaluation and/or research typically occur in an elearning project. This discussion represents evaluation research (stage 6), where inquiry based on evaluation data goes beyond determining the worth and value of the project, and continues with the goal of further understanding developments and changes around learning in the new elearning environment.

Findings and discussion: Realising an effective learning environment

Due to limitations of scope, discussion of evaluation findings has been limited here to four issues. The first relates to the efficacy of the MOOC environment for supporting learners and learning, and is the issue of designing for a culturally and educationally diverse student body with widely divergent motivations and capabilities. The other three findings discussed have institutional implications, namely the need to establish quality parameters for curriculum innovation projects; the contribution of personal and organisational learning to the transformation process; and the need to select the delivery platform early in the MOOC planning and design phase, due to its impact on other learning technologies and the curriculum design process. Where applicable, the source of the data discussed in the findings is indicated in the table notes, after participant comments or the in the ensuing commentary.

Efficacy of the MOOC: Designing for motivation and diversity

The two MOOCs reached a culturally and educationally diverse international audience of 20,718 registrants (C1, N=12,894; C2, N= 7,824), with students enrolling from 161 countries, (see top three locations, Table 1).

<table>
<thead>
<tr>
<th>Course 1 (C1)</th>
<th>Course 2 (C2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enrolments from 161 countries (n=12,894)</strong></td>
<td><strong>161 countries (n=7,824)</strong></td>
</tr>
<tr>
<td><strong>Enrolment (top 3 countries)</strong></td>
<td><strong>Country</strong></td>
</tr>
<tr>
<td>1 Australia</td>
<td>19</td>
</tr>
<tr>
<td>2 India</td>
<td>16</td>
</tr>
<tr>
<td>3 United States</td>
<td>14</td>
</tr>
</tbody>
</table>

*Note:* Other countries included e.g. Egypt, Germany, Brazil, UK, Canada, France and Mexico. Data source: Google analytics.
While survey results indicated that a typical registrant was male (C1 85%, n=5565; C2 88%, n=1687), 20-30 years of age (C1, 52%, n=5570; C2, 53%, n=1685), who had already attained an undergraduate degree or diploma (C1 and C2, 38%; n=5549, n=1685), the full demographic picture of the two robotics courses reveals that 41% of the MOOC registrants did not have university qualifications, and 20% were under 20 years of age for the first robotics course (C1) (the youngest being 10 years old). This most probably reflects the popularity of robotics with young enthusiasts and hobbyists, teachers, and students already undertaking an engineering or robotics course (data from forums and emails). The second course (C2) showed slightly less diversity (down to 13% in the under 20 age group) and may reflect the impact of the increased complexity of the second course. So although the profile of the majority of course registrants fits the norm (according to Ho et al., 2014), closer examination of the analytics revealed a more complex picture of the student cohort.

In terms of motivation, the majority enrolled in the introductory course (C1) for reasons of general interest or enjoyment (77%; n= 5569), but the figure dropped to 25% (n=1689) for the second more advanced course (C2). Professional interest remained the second most popular reason for enrolment in either course (48% C1; 19% C2; see Table 2).

Table 2: Motivation for enrolling (top 5 reasons)

<table>
<thead>
<tr>
<th>Survey responses (n)</th>
<th>%</th>
<th>Course 1</th>
<th>%</th>
<th>Course 2</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>General interest or enjoyment</td>
<td>77</td>
<td>5569</td>
<td>25</td>
<td>1689</td>
<td>12</td>
</tr>
<tr>
<td>Professional interest</td>
<td>48</td>
<td>5569</td>
<td>19</td>
<td>1689</td>
<td>14</td>
</tr>
<tr>
<td>I am studying university level robotics</td>
<td>34</td>
<td>5569</td>
<td>12</td>
<td>1689</td>
<td>14</td>
</tr>
<tr>
<td>Earning a statement of attainment</td>
<td>29</td>
<td>5569</td>
<td>14</td>
<td>1689</td>
<td>12</td>
</tr>
<tr>
<td>To help my employment prospects</td>
<td>24</td>
<td>5569</td>
<td>9</td>
<td>1689</td>
<td>13</td>
</tr>
</tbody>
</table>

Note: Participants could choose more than one option. Data from pre-course surveys.
Source: Philip & Greener (2016, p.13)

As predicted by Stich and Reeves (2017), it is probable that the students who were most likely to succeed in these MOOCs were those who had high motivation for undertaking the courses, well developed study skills, and the digital literacy skills for managing online learning. That is, in terms of teacher defined learning outcomes (passing the assessments and achieving a certificate of participation) they were set up for success. The greater difficulty of persisting with and managing online study compared with face-to face attendance is acknowledged in the literature (e.g. Kovanovic, et al., 2015; Stich & Reeves, 2017).

Students also needed a willingness to tackle the challenging mathematical and programming tasks required of students undertaking the equivalent of a third-year robotics course. 1,096 certificates of participation were issued to students who passed the assessment tasks (multiple choice questions and programming tasks; note the robot making project was optional). Stich and Reeves (2017) argue that MOOCs are particularly dependent on course and participant characteristics, more so than traditional university courses. They also claim that course completion rates for MOOCs have remained at a consistently low rate, 5-12%. This, however, represents a measure of achievement of teacher defined learning outcomes, and does not account for achievement of learner defined outcomes for participants in these open courses. Gasevic, et al. (2015) also recognise this tension between learner motivations and intentions, and institutional expectations. We suggest that this is an area for further research.
Table 3 provides further evidence of the diversity of students tackling the two courses, and the impact of level of difficulty on outcomes. While the first course was an introductory robotics course, it still required a level of mathematics and programming skills as specified in the pre-course information. Three main groups emerged. There were those who used the opportunity to refresh their knowledge and found the course well within their capabilities; others who accepted the challenge and transitioned to a deeper level of learning; and a third group who, despite enthusiasm, struggled with the difficulty of the curriculum (see Table 3).

Table 3: Variation in response to the level of difficulty of the courses

<table>
<thead>
<tr>
<th>Level of difficulty</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struggled with the difficulty</td>
<td>I’m spending many hours per week on the course but I’m still struggling to keep up. (C1, mid-course survey)</td>
</tr>
<tr>
<td>Appreciated the challenge</td>
<td>It is not that easy for someone like me lacking a technical background but it is still a lot of fun, hard but awesome (always loved math) and everything is very well done. (C2, mid-course survey)</td>
</tr>
<tr>
<td></td>
<td>I’m also left with a lot of pride in the progress I made and all that I learnt. I left high school with the impression that I was no good at maths. In this course I really showed myself that I am capable of learning and applying maths - especially when there’s a goal which is so compelling to me. (C1, post-course survey)</td>
</tr>
<tr>
<td>Course perceived as well within student’s capabilities</td>
<td>It is so far a great course. It is very basic. I have already completed a robotics course in University, but this is an excellent refresher course for me. I am looking forward to the vision course after this. (C1, mid-course survey)</td>
</tr>
<tr>
<td></td>
<td>The problems were great. Very interesting. The questions can be harder :) (C2, post-course survey)</td>
</tr>
<tr>
<td></td>
<td>Recommended reading and links to background material make it suitable for diverse audience. (C2, post-course survey)</td>
</tr>
</tbody>
</table>

Source: Philip & Greener (2016, p.18)

**Implications for the institution**

In the early MOOC environment in which our courses were created, a significant number of curriculum issues were negotiated from first principles. Curriculum development was not governed by the rules that normally govern certification and accreditation of higher education courses. The usual standards approval processes did not apply, such as the need to meet university specified graduate capabilities or align with a whole of degree curriculum (internal standards), Engineers Australia professional association standards, or the Tertiary Education Quality and Standards Agency (TEQSA) (external standards). Exposure of the curriculum to a very public world audience was, however, a system of quality control, along with the high professional standards and expertise that university teaching and support staff, and industry partners, brought to the project. Continual stages of evaluation (as illustrated by Figure 1), also contributed to quality standards.

In innovation projects such as this “much learning and research takes place informally on the job” (Philip & Greener, 2016, p.5). There were complex pedagogical, technological and professional learning problems that university staff and industry partners had to quickly, creatively and collaboratively solve. This entailed considerable individual and organisational learning. All stakeholders in the venture, from web designers to teaching assistants, university managers to industry partners, and more, had to be imaginative, prepared to take risks, and deal with uncertainty. Evidence from staff debriefing sessions indicated that some staff
thrived in the new environment, but embedding new processes, structures and management systems in a traditional university was a considerable challenge. The management of creative teams calls for creative leadership (Puccio, Mance, & Murdock, 2011), with supportive and flexible champions for change at all levels of the organisation.

The findings also indicated that selection of the online delivery platform needed to occur well in advance of both curriculum and production work. This was imperative, as learning technologies and pedagogies are interdependent: curriculum decisions impact technology choice and vice versa. Platform choice and course design occurred in parallel, and this impacted assessment options in particular. For example, the tools for automated online assessment were not known or testable early in the project: these were the tools for student peer review of the robot-making project, and automated assessment marking of students’ software programming capabilities. In addition, the full functionality of the online discussion forum was not initially known, as this was still undergoing technical modification. The central importance of communications technologies in online learning environments is well documented (Kovanovic et al., 2015), and this affected preparation of teaching materials, teaching assistant preparation, and the choice of additional applications for synchronous communication. Nonetheless, the university had a unique opportunity to work collaboratively with industry partners in this project, to shape the delivery platform and other technical solutions to meet their own specifications, including a custom-made peer review assessment system. It was a chance to drive technological development in higher education.

Creating new pathways

As a result of the MOOC experiment, new pathways for learning in fully online and blended learning emerged for our institution. These are student learning pathways, and opportunities for strategic diversification for the university. Figure 2 illustrates these trajectories as new economic and pedagogical models, which include open and award courses, free and fee-paying courses, increasingly shorter and more modularised options, and new accreditation pathways. As Figure 2 demonstrates, the process of innovation began with two fully online MOOCs (open courses) and the counterpart undergraduate course (an award course) (stage 1). This was followed by integration and reuse of MOOC resources back into the undergraduate robotics unit, transforming the lecture/tutorial model into a blended, flipped classroom (stage 2). In stage 3 increasing modularisation offers greater learner flexibility through the open course modules, including separate assessment modules. New award courses are being created that target postgraduate students and professional learning opportunities. Accreditation for completion of modules taken in the open courses can lead to recognition of prior learning in new online award courses (see Figure 2).

As a final note, not represented in Figure 2, at the time of writing, the open source, community-based robot academy (Khan Academy style) was confirmed for development. This is a successful outcome for the OER movement and the goal of widening participation, improving access to higher education, and knowledge sharing. Further, these innovations and new pathways are all small steps towards new educational models. Their success or otherwise will inform our understanding of the role and relevance of universities in the future, in an educational landscape that is entrepreneurial and competitive.
New conceptual models of learning

Another pathway that emerged from this project was the pathway towards a new conceptual model for learning. This research prompted us to reflect on how students were learning in the MOOC environment, and how that was different (if at all) to what we knew of other blended and online settings. An understanding of learning is key to curriculum design, so a richer understanding of this is undoubtedly of value. Gasevic, et al. (2015) agree that new theoretical and practical frameworks are necessary to represent what is going on in MOOCs, so we will continue our reflections on this, and preparation of a new conceptual framework for learning in the MOOC environment. The conceptual framework of learning proposed by Phillips, et al. (2012) provides a basis for this research, building as it does on the work of experienced educational theorists such as Biggs, Laurillard, Bain, Reeves, and Goodyear.

Conclusion

Evaluation of the delivery of the robotics MOOCs revealed innovative individual, team and organisational responses to significant challenges. Complex pedagogical, technological and capacity building challenges were negotiated. Findings from the evaluation indicated that institutions need staff who are capable of responding quickly and creatively as innovation projects such as these unfold. The study confirmed the need for a holistic and iterative approach to course design and curriculum transformation, and the value of ongoing formative and summative evaluation as a contribution to MOOC quality. The findings also indicate that the more we learn about the impact of participants’ motivations, educational backgrounds, and disciplinary capabilities, the better we can design suitable online learning environments.
Curriculum innovation in this example was triggered by the MOOC initiative. Preliminary experiments in online and distance delivery at a massive scale led to the development of new learning pathways for students, and new strategic directions for the university. These innovations and curriculum developments are prompting conversations about the related and complex questions that subsequently arise about the role of universities, now and into the future.

Two limitations of the research reported here are that the evaluation is based on only two MOOCs, from the same discipline; and this paper is a discussion of only selected issues from the data, not all the findings. Suggestions for future research include a focus on deepening understanding of students’ patterns of engagement and learning in these evolving online environments; the emergence of new roles for learners, teachers and teaching assistants; networking within and beyond the course; reuse of resources between open and award courses; and strategies for increasing participation in higher education by linking formal and informal learning opportunities.

Acknowledgements

The authors gratefully acknowledge the large team who contributed to this project, including Professor Peter Corke, Associate Professor Michael Milford, MOOC teaching assistants, the design, production and learning analytics team, and industry partners.

References


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302