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TWELVE TIPS

Twelve tips for developing and delivering a massive open online course in medical education

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ABSTRACT

Massive open online courses (MOOCs) are a novel mode of online learning. They are typically based on higher education courses and can attract a high number of learners, often in the thousands. They are distinct from on-campus education and deliver the learning objectives through a series of short videos, recommended readings and discussion fora, alongside automated assessments. Within medical education the role of MOOCs remains unclear, with recent proposals including continuing professional development, interprofessional education or integration into campus-based blended learning curricula. In this twelve tips article, we aim to provide a framework for readers to use when developing, delivering and evaluating a MOOC within medical education based on the literature and our own experience. Practical advice is provided on how to design the appropriate curriculum, engage with learners on the platform, select suitable assessments, and comprehensively evaluate the impact of your course.

Introduction

Massive open online courses (MOOCs) are open access courses created by higher education institutions from around the globe, and hosted on a commercial platform, such as FutureLearn, EdX or Coursera. Although the medical education literature is well populated with computer-based learning approaches (Cook et al. 2008), the potential role of MOOCs in medical education remains under researched (Zemsky 2014; Head 2014; Williams & Nai-Fen 2015; Chapman et al. 2016). Typically, courses are based on conventional higher education programs and combine traditional materials, such as video-based lectures, recommended reading lists, automated online assessments, and discussion fora (Hoy 2014). Due to the open nature of MOOCs, the absence of a subscription fee and with learners only requiring an internet-enabled electronic device for enrollment courses can attract large numbers of learners and form a heterogeneous population of participants. This diverse range of learners can enrich the course beyond what could be delivered by the host institution alone, by sharing their own knowledge and experience with others.

Within medical education the practical use of MOOCs as a learning tool remains unexplored to a meaningful level (Prober & Heath 2012; Mehta et al. 2013; Bateman & Davies 2014; Reich 2015). At present, a range of possible roles have been purposed, including continuing professional development (Gandhi 2013; Murphy & Munk 2013; Power & Coulson 2015; Reinders & de Jong 2016) and interprofessional education (IPE; Kirch & Ast 2014; Pickering & Swinnerton 2017), integration into blended learning curricula (Swinnerton et al. 2016) and enabling

flipped classroom approaches (Prober & Heath 2012; Tucker 2012).

This twelve tips article provides a framework for delivering a MOOC within medical education based on both the literature, and the authors' own experiences and personal perspectives from four MOOCs.

Tip 1

Enroll on a MOOC to fully appreciate the online environment

Participating in a MOOC that is broadly in line with your subject area is the most straightforward approach to gaining insight into this mode of online learning. Putting yourself in the position of a learner and getting a feel for what works, and importantly what does not, will help to create ideas that you could implement with your own course. A straightforward search engine submission will bring up numerous MOOCs that are available to enroll for free, with websites, such as www.mooc.ca and www.class-central.com offering easy access.

Tip 2

Learn from other MOOC enthusiasts

Prior to embarking on the development phase, make sure you are fully aware of the practicalities and time commitment involved. Speaking to a wide range of colleagues from within your medical or healthcare faculty and attending medical education conferences can provide the ideal opportunity to network and engage. Not only will this support

your own personal development, it can potentially lead to collaborations and the creation of a multi-institutional approach to MOOC development. Moreover, attending specialist conferences will open possibilities with current MOOC developers and provide valuable insights into the running of a course. This forum will also highlight the positive impact, such courses can have on individual learners, and importantly, the staff involved in developing the course. Although it is important to fully understand the logistical aspects, appreciating the diverse range of potential benefits this style of open education can have on learners (Liyanagunawardena et al. 2013; Zhenghao et al. 2015; Laurillard 2016; Milligan & Littlejohn 2016), the host institution (Negrea 2013; Jenner 2014), and your own development, are not to be underestimated and should be the main drivers for deciding to embark on this time-consuming journey.

Tip 3

Develop a MOOC topic that you are passionate about

An essential, and probably the most important, step in developing a MOOC is choosing a topic. Ideally, the topic should be focused on an area that you are deeply passionate about as this enthusiasm will come across in the resources you develop. However, you need to be realistic and carefully take into consideration your intended target audience and the MOOC's length (Liyanagunawardena & Williams 2014). A preliminary search of available MOOCs to ensure your topic is not covered already would be prudent, and you should also consider whether the content you wish to deliver lends itself to this style of teaching. Finally, before you confirm the topic you should reach out to potential participants and pitch your idea to assess the need and enthusiasm for such a course. Using these individuals as partners in the creation phase of the MOOC will give an additional perspective (O'Neill & Wyness 2005); after all, they are your potential audience.

Tip 4

Recruit a committed and enthusiastic team to support the MOOC's development and delivery

In order to develop and deliver a successful MOOC, a team of likeminded and committed individuals need to be involved (Kellogg 2013). The team should consist of a lead academic to develop a suitable curriculum, write lecture scripts for video-based content, create learning objectives, and set assessment questions. Recruiting a group of supportive colleagues to help in the review process of this material is also recommended to ensure the content is well presented and delivers the intended learning objectives. This support network should include members who can step in at short notice and help deliver the course in an emergency, and mentors who can interact with the learners on the platform when the course is running. During this recruitment process, consideration should be given to integrate, where possible, the specialist healthcare professionals who are currently delivering the service that is most closely aligned to the course. For example, current MOOCs typically use leading academics, research fellows and PhD students to serve as lead educators and mentors, but for a

medical education MOOC it might be appropriate for a range of healthcare professionals from junior doctors to senior consultants to take on that role. Support for mentoring learners on the MOOC should be provided as faculty development, with some course providers also providing opportunities to learn more about the mentoring role (i.e. <http://www.coursera.community>).

With the majority of MOOCs containing video-based resources colleagues who are trained in audio-visual creation, filming and editing, and who have technical expertise with the MOOC platform are essential. Once all the material is created it will need to be packaged and uploaded in a streamlined and coherent manner. With a MOOC, there is often a story to be told, a flow of activities that lead the learner through a journey. This journey needs to be clear and easy to follow; learning technologists familiar with MOOC design can support you in converting your stand-alone resources into a compelling and engaging story. To support the running of the team, an administrator would be particularly helpful to coordinate the development of the course and ensure self-imposed, and platform provider, deadlines are kept.

Tip 5

Develop a curriculum map to guide the content development

To develop your curriculum map you will need to establish your target audience, what academic level the content is going to cover, and how long the course should last. Then you will need to allocate specific areas of the topic to certain weeks and decide how that content is going to be delivered. Furthermore, you will need to carefully consider how long you expect learners to engage with the MOOC. The majority of learners will be accessing the MOOC periodically due to work commitments (Harder 2013; Glass et al. 2016; Swinnerton et al. 2016), so carefully considering the amount of material contained within each week is essential. This is particularly pertinent if the MOOC is designed for undergraduate or postgraduate medical trainees as they will already have particularly heavy timetables and workloads.

With traditional MOOCs, the majority of content will be delivered through video lectures, but learning at distance requires more than just simple presentations that mimic a recorded lecture; open access texts, discussion and research activities, and automated quizzes, are all required to create a blend of learning opportunities (Zhang & Zhou 2003). Importantly, for each of these activities learning objectives need to be created so the learners are clear what they are expected to know (Reich 2015).

You should tell a story through your curriculum map. Make sure there are clear start and end points so the learners can track their own progress. MOOCs cannot just be repositories of content, there needs to be a logical path, which will provide an educational scaffold for the learners. This is particularly important as progression through the MOOC will rely on considerable self-regulated learning to optimize the learning experience (McAndrew & Scanlon 2013; Milligan & Littlejohn 2014; Milligan & Littlejohn 2016). Opportunities for self-creation and exploration are essential so the learner is not just consuming knowledge by

watching your videos. Posing discussion topics or research questions for learners to investigate in more detail are good approaches, especially if they can then post these findings on the platform for further discussion.

Tip 6

Create a clear project plan

By now it should be clear that the development of a MOOC can be a complex and time consuming process. Therefore, it is important that the MOOC delivery team is committed to the course's design and is clear with the amount of content that needs to be produced. Liaising with the host platform will enable you to have a date for the course to start, and then working back, all of the tasks will need to be scheduled. It is important to appreciate that creating professional videos and other types of media requires considerable time and this needs to be scheduled (Kellogg 2013). From our own experience, it usually takes approximately 12 months to create the content for a MOOC, while also continuing to engage in your regular activities. However, this is not necessarily appropriate for everyone that wishes to develop a MOOC and colleagues may feel that having a full-time commitment would be more suitable. Essentially, before committing to the development of a MOOC clear and unequivocal technical, administrative and academic support needs to be in place.

A typical sequence for creating a video would involve writing a script and making sure it covers the specific learning objectives and instructional design (Zhang & Zhou 2003; Thomson et al. 2014), arranging a suitable time for recording, practicing the script in front of a camera, and then recording. Although presenting in lectures and at conferences can be relatively straightforward for experienced educators, standing in front of a camera is a new skill that should not be taken for granted. Once the recording is complete it will need to be edited and then reviewed by yourself or your mentors to check for factual accuracy. It is highly unlikely that your production team will be competent in the MOOC's topic so it is likely that rounds of review, edit, re-review, and reedit will be needed before the video is finalized. This is an essential part of the development stage as the content you deliver has to be of high quality and factually correct. If your MOOC contains a high number of videos, this process can take considerable time and needs to be properly accounted for in the plan. Once all the resources are created and proofed, time will be needed for aggregation onto the platform and then checked once again that the flow of the course matches the original map.

Tip 7

Create video content based on good educational practice

The main approach to delivering your content will be via video lectures, and these resources need to be clearly supported with learning objectives that match your curriculum. Furthermore, in designing your video content it should follow some well-established approaches. The videos should be short and not exceed 6–7 min (Hsin & Cigas 2013; Guo et al. 2014), you should adopt a conversational style to

development greater student engagement (Mayer 2008), and make sure the content is in context – do not bring in video lectures from previous courses to try and cut corners. If you intend to integrate the MOOC's material into your campus-based curriculum you should create resources that are not tagged with specific descriptors. An approach might be to record two introductions, one that offers a personal touch to the MOOC learner and positions the resource in context, with a second allowing the resource to be used in perpetuity across multiple formats. This will ease the re-purposing process and support the utilization of your high-quality resources in other contexts.

As the videos are developed you should be conscious of cognitive load and design the material accordingly. Educational psychologists have done considerable work in this area (Sweller 1988; Plas et al. 2010), with Mayer (2009) developing a range of principles aimed at reducing cognitive load. Essentially, videos are more effective if the animations and imagery are supported by either narration or text, not both. Being aware of these simple but effective principles will support your learners in successfully achieving the learning objectives. Furthermore, for your video content it is advised that subtitles are added to enable learners with specific learning disabilities to access the material – in fact, certain countries require such additions for learners with hearing disabilities and this would also support those whose first language is something other than the language of instruction. You may also wish to have the audio transcribed so it can be released as a script for learners to download. If the MOOC's topic is particularly complicated the addition of a glossary of commonly used words would be beneficial, and educators should be advised to avoid using overly colloquial or regional idioms.

A final consideration when creating content, it to be sure that you have the appropriate copyright agreements for use on the MOOC platform. This can sometimes be difficult to negotiate and using images may incur a significant fee, which would make the MOOC overly expensive. Due to the open nature of MOOCs, this issue is particularly pertinent and extra measures should be put in place to ensure all material is sufficiently covered to protect against breaches of copyright law. Bear in mind that if you need to hire a scientific illustrator or animator to remedy the issue of imagery access and copyright, this will add significant time to the MOOC's development.

Tip 8

Construct an appropriate assessment profile

When considering what assessments your MOOC will contain the most important consideration is scalability. MOOCs often attract learners in the thousands, and it is important that you can provide feedback that is timely and accurate. The most common format is automated quizzes, which can be located throughout the curriculum and allow learners to monitor their own progress. Multiple-choice questions lend themselves well to online learning, and if functionality allows, the learner should receive detailed feedback on their response. For example, learners who get questions incorrect should be provided with a short explanation as to why and then be directed to the specific resource on the platform that covers the relevant area. Without an

instructor the automated responses need to be prompt so the student can either successfully progress to the next step, or be directed to material for review.

Other forms of assessment within MOOCs are emerging with scale always being the key consideration (Admiraal et al. 2015). These can include automated essay marking, peer assessments, with learners marking other learners work using a set criteria provided by the course instructors, and discussion tasks (Reilly et al. 2014). Specifically, within medical education the integration of virtual patient cases has been used to increase interactivity and foster clinical reasoning skills training (Stathakourou et al. 2014a, 2014b; Subhi et al. 2014).

Ideally, all the assessments used on the course should be bespoke as they will need to specifically match the learning objectives of your curriculum and be of the highest quality. Moreover, MOOC educators who are interested in online learning, but not necessarily experts on writing assessments should consult examination best practice guides (i.e. the National Board of Medical Examinations website). Moreover, although the questions you develop maybe very similar, using questions from your own institutions credit-bearing courses is not advisable to maintain the integrity of your question banks.

Tip 9

Promote your course with a clear and enticing message

Once the start date for the course is known you should begin to promote your course. Some easy targets will be your own local networks, such as your students, alumni and colleagues, to help spread the course details. Creating some simple, and eye catching, flyers and posters to advertise your course is relatively cheap, and can be used for networking events and conferences.

Although local networks will enable you to advertise your course within your sphere of influence, you should also go for a global audience. The most obvious way to achieve this is to use social media, which has an emerging and diverse role in medical education (Bosslet et al. 2011; Cheston et al. 2013; Roy et al. 2016). Platforms, such as Facebook, Twitter and YouTube have incredible reach, and with a clear and enticing message your course can spread very quickly. Each social media communication should be clear, provide information about the course and how learners can sign up. A brief, 2–3 min trailer is essential and this can be disseminated through these channels to efficiently provide details on content, academic level and course duration. Other posts could include short sections from videos that are used during the course to highlight the professional standard of resources that the learners would be receiving. A strong, clear social media campaign can have great reach and disseminate your course to interested individuals around the globe.

Tip 10

Provide a supportive environment for your learners to interact with

The majority of MOOCs lack the support structures of an on-campus course, resulting in learners having to exhibit a

high-degree of self-regulated learning (McAndrew & Scanlon 2013). To support the learner, sufficient guidance on how to interact with the MOOC and a suggested course pathway are essential. Moreover, as many of the learners will be in full-time employment (Glass et al. 2016), emphasizing the flexibility of the course structure is also important. Different learners will interact with your MOOC to varying levels, with some following the pathway very precisely, and others engaging only with resources that match their own specific needs. As MOOCs are open learning spaces that are dependent on learner–learner, and learner–mentor interaction, it is important to be clear how accessible the mentors will be. You may want to think of scheduling when specific mentors are online so there is always a presence, or that the mentors will only respond to comments that match the course pathway. An additional approach to interact with your learners is to host live question and answer sessions, where mentors are online at a specific time and learners know that if they post a comment during this period they will receive a prompt reply. Various software solutions can support this development, and you will probably want to have some technical support to ensure the session goes according to plan. Although the time when you hold the session can vary, to cater for all learners recording the session for asynchronous viewing by those in different time zones would be a much appreciated approach. Alternatively, live sessions could be run multiple times each day or colleagues from collaborating institutions around the world could run them to cater for specific groups.

This tip is particularly important as MOOCs offer the opportunity to not only share knowledge and resources, but to provide opportunities for rich and diverse discussion with a wide range of practitioners and the public. For example, recent studies have highlighted the potential for MOOCs to support professional development of healthcare professionals (Gandhi 2013; Murphy & Munk 2013; Power & Coulson 2015; Reinders & de Jong 2016; Pickering & Swinnerton 2017), and although much more work is needed, it is clear that if the correct conditions (i.e. platform capability, mentoring availability, and learner profile) are available this mode of online learning can serve a clear supportive purpose.

Tip 11

Devise a broad research and evaluation strategy for post-course reflection and improvement

Although it is widely appreciated that computer-based learning is effective (Cook et al. 2008; Cook 2009), further research needs to focus on when and how to utilize MOOCs for individual contexts. Although some strategies have been suggested, the approach to evaluating MOOC efficacy is under-developed (Chapman et al. 2016). From our own experience, a comprehensive strategy should entail three streams. Firstly, the platform host will provide enrollment and completion rate data, alongside results from a pre- and post-course questionnaire, which will allow you to identify some patterns of engagement across the whole course. However, drawing meaningful and contextual information from this data can be difficult. For example, completion rates mean very little without knowledge of the individual learners' motivations; similarly, discussions on

gender distribution is difficult without understanding the distribution across the specific subject matter (Glass et al. 2016).

To understand specific learner motivations a second, more targeted, approach should be employed. To do this a separate questionnaire should be constructed that specifically asks a subgroup of your total learners (i.e. postgraduate students or healthcare professionals), to comment on their unique motivations, engagement patterns and self-perceived individual benefits. A final approach should target the *invisible learner* (Veletsianos 2015). The specific impact MOOCs have on individual learners can easily be lost amongst all the data and statistics. As these learners will be experiencing an educational resource that would otherwise be unavailable, it is important to obtain personal views of the MOOC's tangible impact. Only by understanding this impact, can modifications and improvements be made for future iterations.

Tip 12

Share your experience to further enhance MOOC pedagogy

Hopefully having delivered your MOOC it would have been successful, and received positive and constructive feedback. You should share this information with colleagues locally and feedback your personal experience to your team, especially if they are going to continue making MOOCs with other colleagues on different topics. Moreover, as research on the utility of MOOCs is still under-developed within medical education (Reich 2015), your MOOC data and experience should be written-up and published where possible as conference papers or journal manuscripts. In order to develop a conceptual framework for the effective integration of MOOCs in medical education understanding their impact, what works and what does not is essential, so please share your story.

Conclusions

Embarking on the design and development of a MOOC can be a daunting experience, due to the high profile and large number of learners that this mode of online learning can attract. By establishing a clear rationale for developing the course, an appropriate and engaging curriculum, alongside innovative and well-designed content, MOOCs can provide educational opportunities for a broad range of healthcare professionals and students. Although the commitment required should not be underestimated and having a team of dedicated individuals is essential, the creation of these resources and the engagement with learners on the MOOC platform can be particularly rewarding.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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References

- Admiraal W, Huisman B, Pilli O. 2015. Assessment in massive open online courses. *EJEL*. 13:207–216.
- Bateman J, Davies D. 2014. The challenge of disruptive innovation in learning technology. *Med Educ*. 48:227–228.
- Bosslet GT, Torke AM, Hickman SE, Terry CL, Helft PR. 2011. The patient-doctor relationship and online social networks: results of a national survey. *J Gen Intern Med*. 26:1168–1174.
- Chapman SA, Goodman S, Jawitz J, Deacon A. 2016. A strategy for monitoring and evaluating massive open online courses. *Eval Program Plann*. 57:55–63.
- Cheston CC, Flickinger T, Chisolm MS. 2013. Social media use in medical education: a systematic review. *Acad Med*. 88:893–901.
- Cook DA. 2009. The failure of e-learning research to inform educational practice, and what we can do about it. *Med Teach*. 31:158–162.
- Cook DA, Levinson AJ, Garside S, Dupras DM, Erwin PJ, Montori VM. 2008. Internet-based learning in the health professions: a meta-analysis. *JAMA*. 300:1181–1196.
- Gandhi H. 2013. Technology to aid continuous professional development. *InnovAIT Educ Inspir General Pract*. 7:241–246.
- Glass CR, Shiokawa-Baklan MS, Saltarelli AJ. 2016. Who takes MOOCs. *New Dir Inst Res*. 2015:41–55.

- Guo PJ, Kim J, Rubin R. 2014. How video production affects student engagement: an empirical study of MOOC videos. In: *Proceedings of the first ACM Learning @ scale conference*; New York, NY: MIT; p. 41–50.
- Harder B. 2013. Are MOOCs the future of medical education? *BMJ*. 346:f2666.
- Head K. 2014. Are MOOCs the future of general education. *JGE*. 63:244–255.
- Hoy MB. 2014. MOOCs 101: an introduction to massive open online courses. *Med Ref Serv Q*. 33:85–91.
- Hsin WJ, Cigas J. 2013. Short videos improve student learning in online education. *J Comput Sci Coll*. 28:253–259.
- Jenner M. 2014. What's the benefit of MOOCs? Digital education team blog [Internet]. [cited 2016 Sept 27]. Available from: <http://blogs.ucl.ac.uk/digital-education/2014/03/25/whats-the-benefit-of-moocs/>
- Kellogg S. 2013. Online learning: how to make a MOOC. *Nature*. 499:369–371.
- Kirch DG, Ast C. 2014. Interprofessionalism: educating to meet patient needs. *Anat Sci Educ*. 8:296–298.
- Laurillard D. 2016. The educational problem that MOOCs could solve: professional development for teachers of disadvantaged students. *Res Learning Technol*. 24:1–17.
- Liyagunawardena TR, Williams SA. 2014. Massive open online courses on health and medicine: review. *J Med Internet Res*. 16:e191.
- Liyagunawardena TR, Williams S, Adams A. 2013. The impact and reach of MOOCs: a developing countries' perspective. *eLearning Papers*. 33:1–8.
- Mayer RE. 2008. Applying the science of learning: evidence-based principles for the design of multimedia instruction. *Am Psychol*. 63:760–769.
- Mayer RE. 2009. *Multi-media learning*. 2nd ed. Cambridge, UK: Cambridge University Press.
- McAndrew P, Scanlon E. 2013. Education. Open learning at a distance: lessons for struggling MOOCs. *Science*. 342:1450–1451.
- Mehta NB, Hull AL, Young JB, Stoller JK. 2013. Just imagine: new paradigms for medical education. *Acad Med*. 88:1418–1423.
- Milligan C, Littlejohn A. 2016. How health professionals regulate their learning in massive open online courses. *Internet High Educ*. 31:113–121.
- Milligan C, Littlejohn A. 2014. Supporting professional learning in a massive open online course [Internet]. *IRRODL*. 15:5. [cited 2016 Oct 4]. Available from: <http://www.irrodl.org/index.php/irrodl/article/view/1855>
- Murphy K, Munk P. 2013. Continuing medical education: MOOCs (massive open online courses) and their implications for radiology learning. *Can Assoc Radiol J*. 64:165.
- Negrea S. 2013. Colleges and universities begin to assess the benefits of MOOCs [Internet]. *University Business* [cited 2016 Sep 30]. Available from: <https://www.universitybusiness.com/article/colleges-and-universities-begin-assess-benefits-moocs>
- O'Neill BJ, Wyness MA. 2005. Student voices on an interprofessional course. *Med Teach*. 27:433–438.
- Pickering JP, Swinnerton BJ. Forthcoming 2017. An anatomy massive open online course as a continuing professional development tool for healthcare professionals. *Med Sci Edu*.
- Plas JL, Moreno R, Brunken R (eds). 2010. *Cognitive load theory*. 1st ed. New York, NY: Cambridge University Press.
- Power A, Coulson K. 2015. What are OERs and MOOCs and what have they got to do with prep? *Br J Midwifery*. 23:282–284.
- Prober CG, Heath C. 2012. Lecture Halls without lectures—a proposal for medical education. *N Engl J Med*. 366:1657–1659.
- Reich J. 2015. Education research. Rebooting MOOC research. *Science*. 347:34–35.
- Reilly ED, Stafford RE, Williams KM, Corliss SB. 2014. Evaluating the validity and applicability of automated essay scoring in two massive open online courses [Internet]. *IRRODL*. 15:83–98. [cited 2016 Oct 4]. Available from: <http://www.irrodl.org/index.php/irrodl/article/view/1857/3067>
- Reinders MEJ, de Jong PGM. 2016. Innovating clinical kidney transplant education by a massive open online course. *Transpl Immunol*. 38:1–2.
- Roy D, Taylor J, Cheston CC, Flickinger TE, Chisolm MS. 2016. Social media: portrait of an emerging tool in medical education. *Acad Psychiatry*. 40:136–140.
- Stathakou N, Zary N, Kononowicz AA. 2014a. Beyond xMOOCs in healthcare education: study of the feasibility in integrating virtual patient systems and MOOC platforms. *PeerJ*. 2:e672.
- Stathakou N, Zary N, Kononowicz AA. 2014b. Virtual patients in massive open online courses—design implications and integration strategies. *Stud Health Technol Inform*. 205:793–797.
- Sweller J. 1988. Cognitive load during problem solving: effects on learning. *Cogn Sci*. 12:257–285.
- Swinnerton BJ, Morris NP, Hotchkiss S, Pickering JD. Forthcoming. 2016. The integration of an anatomy massive open online course (MOOC) into a medical anatomy curriculum. *Anat Sci Educ*. 10:53–67.
- Subhi Y, Andresen K, Rolskov Bojsen S, Mørkeberg Nilsson P, Konge L. 2014. Massive open online courses are relevant for postgraduate medical training. *Dan Med J*. 61:A4923.
- Thomson A, Bridgstock R, Willems C. 2014. 'Teachers flipping out' beyond the online lecture: maximising the educational potential of video. *JLD*. 7:67–78.
- Tucker B. 2012. The flipped classroom: online instruction at home frees class time for learning. *Educ Next*. 12:82–83.
- Veletsianos G. 2015. The invisible learners taking MOOCs. *Inside higher ed*. [Internet] [cited 2016 sept 27]. Available from: <https://www.insidehighered.com/blogs/higher-ed-beta/invisible-learners-taking-moocs>
- Williams V, Nai-Fen S. 2015. Much a MOOC about nothing: is real research coming? *IJEL*. 14:373–383.
- Zemsky R. 2014. With a MOOC MOOC here and a MOOC MOOC there, here a MOOC, there a MOOC, everywhere a MOOC MOOC. *JGE*. 63:237–243.
- Zhang D, Zhou L. 2003. Enhancing e-learning with interactive multimedia. *IRMJ*. 16:1–14.
- Zhenghao C, Alcorn B, Christensen G, Eriksson N, Koller D, Emanuel EJ. 2015. Who's Benefiting from MOOCs, and Why. *Harvard Business Review* [Internet]. [cited 2016 Sep 17]. Available from: <https://hbr.org/2015/09/whos-benefiting-from-moocs-and-why>