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The Integration of an Anatomy Massive Open Online Course (MOOC) into a Medical Anatomy Curriculum

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Massive open online courses (MOOCs) are designed as stand-alone courses which can be accessed by any learner around the globe with only an internet-enabled electronic device required. Although much research has focused on the enrolment and demographics of MOOCs, their impact on undergraduate campus-based students is still unclear. This article explores the impact of integrating an anatomy MOOC in to the anatomy curriculum of a year 1 medical degree program at the University of Leeds, United Kingdom. The course did not replace any teaching that was already being delivered, and was used to supplement this teaching to support the students' consolidation and revision. Analysis of student feedback indicates a high level of usage, with evidence to suggest that female learners may have approached the course in a more personalized manner. Although the video based resources and quizzes were greatly appreciated as learning tools, significant evidence suggests the students did not engage, or were inclined to engage, with the discussion fora. Furthermore, a significant majority of students did not want the MOOC to replace the existing teaching they received. Given the feedback provided, this research suggests that although the student population believe there to be value in having access to MOOC material, their role as replacements to campus-based teaching is not supported. Details regarding the enrolment and engagement of the general public with the MOOC during the two runs are also documented, with the suggestion that graduates employed in the healthcare sector were the primary users of the course. Anat Sci Educ 10: 53–67. © 2016 American Association of Anatomists.

Key words: gross anatomy education; undergraduate education; medical education; medical curriculum; massive open online course (MOOC); course assessment; campus-based students

INTRODUCTION

Anatomy remains an essential component of medical schools across the globe, with its learning being an essential part of any aspiring doctors' training. However, due to a number of factors the approach to anatomical education can vary between institutions (Sugand et al., 2010), with the traditional dissection based approach being modified and replaced with other teaching modalities such as cadaveric prosections, body painting, plastic models, and various aspects of technology (Guttmann et al., 2004; Drake et al., 2009; Finn and McLachlan, 2010). Issues such as the availability of cadavers and the logistical requirements of maintaining a specialist facility are also influencing curriculum design and contributing to the ongoing debate regarding the teaching of anatomy to medical students (McLachlan et al., 2004; McLachlan and Patten, 2006). A popular and ever expanding approach to teaching anatomy is with the use of technology to either support, or fully replace, the existing cadaver based teaching (Wright, 2012; Attardi et al., 2015; Mathiowetz et al., 2016). Moreover, a number of technology-enhanced learning (TEL) resources such as two-dimensional (2D) and three-dimensional (3D) applications (Evans, 2011; Lewis et al.,

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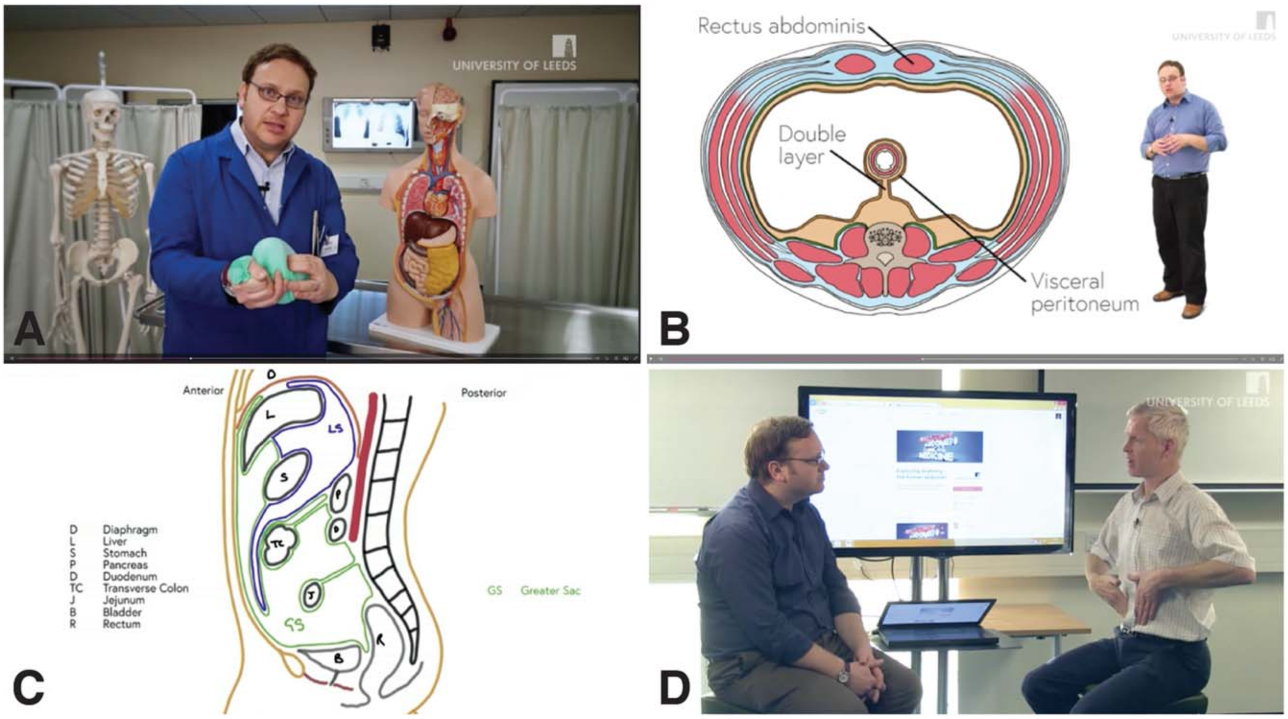

Figure 1.

Screenshots taken from the FutureLearn platform (The Open University, Milton Keynes, United Kingdom) to reveal the range of levels available to the learner with **A**, introductory material; **B**, core material; **C**, advanced material; and **D**, discussion videos.

2014; Pickering, 2015a), eBooks (Mayfield et al., 2013; Stirling and Birt, 2014; Pickering, 2015b; Stewart and Choudhury, 2015) social media (Jaffar, 2014; Raikos and Waidyasekara, 2014) lecture webcasts (Attardi et al., 2015; Vaccani et al., 2016), 3D printing of replica specimens (McMenamin et al., 2014; O'Reilly et al., 2016) and discussion fora (Choudhury and Gouldsborough, 2012; Green et al., 2014) are increasingly being embedded into the existing anatomy curriculum to support cadaver based teaching. Due to the increasing and near ubiquitous availability of internet enabled electronic devices (Chen et al., 2015), such approaches to anatomy learning are becoming prevalent in modern anatomy curricula. These developments are timely, and necessary, as the need for anatomy teaching remains but is faced with time and curricula constraints within the context of a whole medical course (Heylings, 2002; Granger, 2004; Turney, 2007; Bergman et al., 2008; Cooper and Gray, 2014). In light of this changing anatomy teaching environment, this article investigates the impact of integrating a massive open online course (MOOC) into an anatomy course.

Development and Delivery of the Leeds Anatomy MOOC

Background and context. A recent addition to the TEL education landscape has been the MOOC. These are open access courses typically created by a University and then hosted on a commercial platform for access by learners around the globe without a subscription or enrolment fee. Although they have been popular in the United States since their inception in 2008, when George Siemens and Stephen Downes facilitated the "Connectivism and Connective Knowledge" course (Downes, 2011), the higher education sector in the United Kingdom has only fully embraced MOOCs since 2013 when the commercial platform FutureLearn went live (FutureLearn, 2016).The wide appeal of MOOCs is due to their ability to breakdown barriers to education and provide high-quality teaching resources to all learners around the globe without a financial cost to the learner (Leckhart and Chesire, 2012; Liyanagunawardena et al., 2013). In fact, only an internet enabled device is required to access the course and with 86% of UK households having access to the internet there is great potential to reach into people's homes (ONS, 2015). Since the introduction of MOOCs a number of healthcare courses have been delivered which can provide a range of benefits to all healthcare students and the wider public (Liyanagunawardena and Williams, 2014). These can include: (1) continuing medical education (CME) or continuing professional development (CPD) for graduate or postgraduate learners; (2) integration into campus-based curricula for undergraduate learners; (3) health literacy and public education; and (4) patient education.

Rationale. Due to the integration of TEL into anatomical education, and with the benefit this type of resource could potentially have on individual students across the globe, the School of Medicine and Digital Learning Team at the University of Leeds, United Kingdom, designed and developed an anatomy MOOC—Exploring anatomy: the human abdomen. Alongside the host institution's own cohort of medical and biomedical students, the course was targeted to a range of

Table 1.

An Outline of the Course Material Over the Three Weeks Indicating the Range and Level of Material Provided to the Learner

Week/session	Activity 1	Activity 2	Activity 3
Week 1	Anterior abdominal wall	Peritoneum	Inguinal hernias
Introductory	1. An introduction to the anterior abdominal wall	1. An introduction to the peritoneum	1. A clinical introduction to week 1 2. An introduction to inguinal hernias
Core lectures	1. Anterior abdominal wall and rectus sheath 2. Inguinal canal	1. The structure of the peritoneum 2. The omenta and peritoneal ligaments	
Advanced	1. An advanced look at the muscle of the anterior abdominal wall 2. An advanced look at the rectus sheath 3. An advanced look at the inguinal canal	1. An advance look at the peritoneum 2. An advanced look at the peritoneum: the greater and lesser sac	
Discussion			Surgeon—inguinal hernias
Week 2	**Esophagus, stomach, and intestines**	**Liver, gall bladder, pancreas, and spleen**	**Colorectal tumors**
Introductory	1. An introduction to the gastrointestinal tract	1. An introduction to the accessory organs of digestion and spleen	1. A clinical introduction to week 1
Core lectures	1. The gastrointestinal tract (I) 2. The gastrointestinal tract (II)	1. The liver 2. The gall bladder, pancreas and spleen	
Advanced	1. An advanced look at the disposition of viscera 2. An advanced look at the branches of the coeliac trunk 3. An advanced look at the mesenteric arteries	1. An advanced look at the portal system 2. An advanced look at the biliary system 3. An advanced look at the blood supply to the pancreas and duodenum	
Discussion			1. Surgeon—colorectal tumor removal 2. Pathologist—sectioning, analysis and diagnosis
Week 3	**Posterior abdominal wall**	**Nerves of the abdomen**	**Hepatocellular carcinomas**
Introductory	1. An introduction to the posterior abdominal wall	1. An introduction to the nerves of the abdomen	1. A clinical introduction to week 3 2. Research discussion—from basic science to the bedside
Core lectures	1. Muscles, vessels and viscera of the posterior abdominal wall	1. The autonomic nerves of the abdomen	
Advanced	1. An advanced look at the posterior abdominal wall 2. An advanced look at the vessels of the posterior abdominal wall 3. An advanced look and the kidneys	1. An advanced look at the autonomic nerves of the abdomen	
Discussion			1. Radiologist—approaches to hepatocellular carcinoma treatment

external learners. Firstly, pre-university medical, dental, biomedical science, or allied healthcare students who were interested in applying for a course which contained an element of anatomy and wanted an insight into the curriculum coverage. This insight would support them in making an informed choice as to their future education and career path. Secondly, current undergraduate students who are studying medicine, biomedical science, or any allied healthcare disciplines, at similar institutions, to complement their current anatomy curriculum or add a strand of anatomy to diversify their learning portfolio. Thirdly, current medical practitioners or allied healthcare professionals who might wish to re-engage in an area of anatomy as part of a CME/CPD program. The recruitment of this latter group of learners was an important consideration as it was hoped they would bring their own experience to the course and highlight how understanding the basic science relates to clinical practice, in a way that could support and inspire future healthcare practitioners.

The course has to date been delivered twice on the FutureLearn platform with the first run in the Autumn of 2013 being only the second MOOC that the University delivered. MOOCs are a novel and developing area of education delivery and thus understanding their role, impact and utility in supporting anatomical education to a wide audience is essential to enrich the ongoing debate as to their role in medical, and the wider, education sector (Harder, 2013; Bateman and Davies, 2014; Reich, 2015). When the course was first delivered the focus of the post-course analysis was on the public uptake and reaction to the MOOC (open phase), with the second run being timed to coincide with the delivery of the School's abdominal anatomy curriculum as part of the MBChB (Bachelor of Medicine and Surgery) program (campus phase).

Course design. The ability of MOOCs to provide a diverse range of learners with varied learning opportunities is a fundamental component of their popularity (Kellogg, 2013) and, therefore, the need to provide a range of resources which learners from all backgrounds could engage with was a guiding principle in developing the course. With this philosophy dictating the design of the course, introductory, core, and advanced materials were designed and developed (Fig. 1 and Table 1). Course materials included a variety of multimedia, video-based, learning resources such as: short (five to seven minutes) introductory scene setting videos using basic anatomical models to outline the position and relations of structures (Fig. 1A); bespoke mini-lectures using hand-drawn and animated anatomical images to explore these structures in more detail and introduce important functional aspects (Fig. 1B); and finally, detailed screencasts explaining anatomical structures (Fig. 1C). To provide clinical context, interview-style videos with the lead educator and a surgeon, pathologist, radiologist or basic science researcher to link the structure and function of the relevant area outlined to common clinical scenarios and on-going research, were developed (Fig. 1D). This set of resources would allow for the key anatomical structures and their function to be understood and then placed in clinical context, allowing learners from all backgrounds to gain an insight into the anatomy, current medical practice and basic science research. Moreover, with a range of multilevel resources the learner would be in control of their learning and could select when, where, how, and what aspects of the course they wanted to engage with. As a social learning platform FutureLearn also enables learners to engage in discussions with educators and peers alongside the learning materials, providing context and purpose to discussions. These elements were also available throughout the course.

The learning resources were organized into a three-week course with each week following a similar format and containing three activities. The first two activities of each week covered two areas of the abdomen with the third activity drawing the previous activities together with clinical case studies and links to current medical research. For example, in week 1 the first activity outlined the anterior abdominal wall and examined the various musculo-membranous layers that form the rectus sheath and inguinal canal, with the second activity outlining the complex arrangement of the peritoneum. The third and final activity in week 1 linked these two areas and put them into clinical context with inguinal hernias being discussed with the lead educator interviewing a surgeon on the presentation and surgical management (Table 1).

To support goal setting, which has been shown to facilitate adult learning (Lau, 2014), and allow the learners to monitor their own progress, learning objectives were created for each learning resource and formative assessments with instant feedback were developed and positioned throughout each week. Furthermore, to allow for interaction between the individual learners and the lead educator a range of interactive fora were developed. These included: (1) comment sections associated with each resource, which allowed learners to ask specific questions on areas they had not understood or to seek further clarification; (2) a research and discussion area for each week, where learners could add their own experience and present research findings; and (3) a weekly live synchronized question and answer session, where learners could get real time answers to any queries. To provide further support and to take into consideration learners with accessibility needs or poor network bandwidth, additional material such as transcripts, subtitles, and audio recordings were also provided to encourage engagement and support the video resources.

Research questions. The impact of MOOCs on undergraduate and postgraduate medical education is an area of debate with their role as yet to be fully evaluated. In order to inform this current debate, the demographics, utility and applicability to a current undergraduate course were evaluated after two runs of the MOOC, alongside the impact of an anatomy MOOC on the general public. This study, therefore, addressed the following research questions:

1. What is the general public appeal of a university level online course on anatomy?
2. What impact does a MOOC have on campus-based medical students in regard to: (a) engagement and (b) gender?

MATERIAL AND METHODS

In order to answer the two research questions, the study was split into two phases. An open phase sought to analyze the general impact of delivering an anatomy MOOC on the general public and the uptake by certain groups of individuals. A campus phase was then specifically designed to assess the impact of a MOOC on campus-based students simultaneously undertaking the relevant anatomy part of their MBChB curriculum.

Open Phase Data Collection

Data on enrolment, engagement and demographics for the open phase was generated by the online analytics captured by the FutureLearn platform and the course survey. The pre- and post-course surveys are used to collect the demographic data of the learners prior to completing the MOOC (pre-course survey) and how they engaged with the MOOC upon completion. As with all questionnaire based data retrieval methods it is often the engaged participants who complete the surveys and therefore the data and findings put forward are only representative of this cohort. To ensure demographic and engagement data were reflective of a participant who had engaged with the MOOC to a meaningful level, only participants who had completed a minimum of two steps were analyzed (a step is an individual learning resource within an activity). This cohort of participant is termed a *learner*. In order to maintain continuity of learners from pre-course to post-course survey a unique identification number was allocated to the pre-course survey completers and then carried over to the post-course survey. The course has been delivered twice to date: initially in October 2013 and then repeated in March 2015, with data from both collated and analyzed.

Campus Phase Student Group and the Leeds Anatomy Curriculum

All year 1 medical (MBChB) students at the University of Leeds, School of Medicine study the anatomy of the human trunk as part of an integrated module (Body Systems). This module examines the anatomy, physiology, and relevant clinical considerations of the functional systems within the human trunk as individual strands (respiratory, cardiovascular, gastrointestinal, renal, and reproductive). Students were encouraged to participate in the second run of the MOOC which was timed to coincide with the gastrointestinal and renal strands and therefore support their consolidation and revision of this material. As part of the gastrointestinal and renal strands there were two didactic gross anatomy lectures, six dissection-based practical anatomy classes, one living anatomy, and one radiology small group session. To support these teacher-led sessions there was a number of additional self-directed learning resources including a paper-based workbook, online formative multiple choice questions (MCQs), cadaver demonstration videos, and several other online resources.

The students were directed to the second run of the MOOC (March 2015) via the gastrointestinal strand's introductory lecture, a formal announcement via the University's virtual learning environment and informally via ad hoc announcements during teaching sessions. Although it was suggested that this additional resource would support their consolidation and revision of the teacher-led sessions, the students were under no obligation to take part in the course and enrolment was voluntary. The abdomen curriculum for the MOOC was based on the Leeds MBChB anatomy curriculum.

Campus Phase Data Collection

Data for this phase of the study were collected via a mixed-methods approach upon completion of the course. A specific questionnaire was devised for the campus based students and a focus group was held once the MOOC had finished. The focus group was conducted with current MBChB undergraduate volunteers ($n = 6$) who had enrolled on the MOOC, with the students being denoted 1–6 and [PX] used to identify their individual comments from the focus group transcript (Stalmeijer et al., 2014). Qualitative feedback was also obtained from two free-form questions at the end of the questionnaire, with various themes identified and related comments associated with these. Only themes that matched four or more comments have been presented. The focus group session was held and lasted for approximately 45 minutes. Two dictaphones (SONY IC Recorder, IC-PX312; Sony Corp., Tokyo, Japan) were used to record the conversations which were subsequently transcribed verbatim by an independent member of Faculty not associated with the project; light refreshments were provided for the student volunteers. The record of the conversation was read by two of the four authors (B.J.S. and J.D.P.) with quotes extracted and assigned to one of the themes generated from the questionnaire.

Ethical Considerations

The evaluation of course feedback provided by FutureLearn was conducted in accordance with the FutureLearn Code of Practice on Research Ethics. Ethical approval for the campus phase was obtained from the University's Research and Ethics committee (reference: MREC 15-002). As the MBChB anatomy curriculum lead who developed and delivered the MOOC is familiar with the student group, J.D.P. was not present during the focus group which was conducted by a member of the research team (B.J.S.).

Data Analysis

Data sorting and analysis was performed using Microsoft Excel 2015, version 15.14 (Microsoft Corp., Redmond, WA) with statistical analysis performed in Statistical Package for Social Sciences, version 22 (IBM Corp., Armonk, NY). Likert scale data is presented as mean ± deviation of the mean in parentheses, with the percentage of students agreeing with statements also detailed (Boone and Boone, 2012). A Cronbach's alpha between 0.70 and 0.95 was deemed appropriate (Tavakol and Dennick, 2011). Chi-squared (χ^2) data is reported with degrees of freedom and the sample size in parentheses, the chi square value (to two decimal places) and the significance level, with $P < 0.05$ deemed as significant.

RESULTS

Open Phase

Enrolment and engagement. The total number of enrolments for each run of the MOOC were 8,597 (run 1) and 9,786 (run 2), respectively. Of these enrolments for run 1, 4,762 (55.4%) viewed at least one step and 4,382 (51.0%) viewed a minimum of two steps. For run 2, 4,466 (45.6%) viewed at least one step and 4,097 (41.9%) viewed a minimum of two steps. The latter enrolments who viewed a minimum of two steps are considered "learners" and of these 523 (11.9%) and 888 (21.7%) completed a pre-course survey for run 1 or run 2, respectively. All the following engagement and demographic results for phase 1 of the study are drawn from these two cohorts of learners.

Engagement data for the two runs show that, on average, each individual learner viewed more steps in run 1 (30.8 ± 27.6) than run 2 (21.09 ± 16.3). As can be seen in

Table 2.

Comparison Between the Learner Engagement Levels From Run 1 and 2 of the MOOC

Learner engagement	Number of learners *n* (%)	
	Run 1	Run 2
Viewed steps in week 1 only	2,176 (49.7)	2,085 (50.9)
Viewed every step	569 (12.9)	754 (18.4)
Completers	258 (5.9)	151 (3.7)
Viewed first step (1.1—Planning your journey)	3,537 (80.7)	3,705 (84.6)
Viewed final step (3.20—Tutor reflection)	730 (16.7)	925 (21.1)

Table 2, run 1 and 2 had a similar number of learners only viewing steps in week 1 of the course. However, run 2 had a greater proportion of learners viewing every step, while run 1 had a greater number of learners who completed at least 50% of the steps and all of the assessments (online quizzes). This degree of engagement varied significantly between runs, χ^2 (2, $n = 5{,}993$) = 55.8, $P < 0.001$. The number of learners who viewed the first and last steps of the course (Planning Your Journey and Tutor Reflection) also varied, with run 2 having significantly more learners completing these steps, χ^2 (1, $n = 8{,}898$) = 11.91, $P < 0.001$.

Demographic characteristics of the anatomy MOOC learners. Analyzing the pre-course survey data of learners reveals data regarding gender, age, employment status and sector, and prior education.

Across both runs of the MOOC there were 406 (30.1%) learners who identified as male and 942 (69.9%) as female. This distribution by gender did not vary significantly between runs, χ^2 (1, $n = 1{,}348$) = 2.26, $P = 0.13$, with 144 (27.8%) male and 375 (72.3%) female learners in run 1 and 262 (31.6%) male and 567 (68.4%) female learners in run 2. With regard to the age of learners a broad distribution was observed across both runs of the MOOC, with median ages of 38.7 years and 42.8 years for runs 1 and 2, respectively. The distribution of age for both runs of the course presented in Figure 2 reveals a similar number of learners within each age band for both runs of the MOOC, with this distribution not varying significantly between runs, χ^2 (6, $n = 1{,}344$) = 11.53, $P = 0.07$. Although the distribution of age did not vary significantly, the largest group of learners were within the 18–25 years band, with fewer learners observed at the upper (>66) and lower (<18) years band. Learners within the 26–65 years bands were evenly distributed. Figure 2 also provides a breakdown of gender within each age range for each run of the MOOC alongside the overall gender distribution. Despite some slight variations this remained closely associated and there was no variation in age distribution between genders for run 1, χ^2 (6, $n = 519$) = 4.58, $P = 0.6$; run 2, χ^2 (6, $n = 825$) = 9.73, $P = 0.14$; or when both runs of the course were combined, χ^2 (6, $n = 1{,}344$) = 9.16, $P = 0.16$. A notable exception was the above 66-year-old age range for run 2, which appeared to have an increased number of males, and reduced females.

The employment status of learners was also obtained with each learner identifying with one of the following categories: "in full time work," in part time work," "looking for work," "in full time education," "retired," or "unable to work." These were then grouped into one of three groups: full time or part time employment, full time education, or not in work. Overall for both runs of the course, there were 690 (51.8%) full time or part time workers, 302 (22.7%) in full time education, and 340 (25.5%) not in work. Figure 3A reveals the distribution of learners by employment status with the highest number of learners being in full or part time employment. This distribution was maintained across runs with no significant variation being observed, χ^2 (5, $n = 1{,}332$) = 3.21, $P = 0.20$. Moreover, the gender distribution within each employment status grouping (Fig. 3A) was also consistent with no variation in run 1, χ^2 (5, $n = 516$) = 31.87, $P = 0.39$; run 2, χ^2 (5, $n = 816$) = 3.60, $P = 0.17$; or when both runs of the course were combined, χ^2 (5, $n = 1{,}332$) = 1.82, $P = 0.40$. For those learners who were in full or part time employment the specific sector in which they worked was also gathered with a wide range of sectors provided. Learners who selected *health and social care*, *teaching and education*, and *science and pharmaceuticals* were grouped separately, with the remaining learners classified as *other*. The *other* grouping included a broad range of employment sectors from accounting to transport. Overall for the two runs of the course the majority, 346 (49.6%), of learners identified with the *health and social care* sector, 96 (13.7%) with *teaching and education*, and 38 (5.4%) with *science and pharmaceuticals*. A large number of learners, 221 (31.5%), identified with the sector classified as *other*. Figure 3B outlines the distribution of learners by employment sector for each run of the course, and clearly reveals an increased number of learners involved in the *health and social care* sector, compared with the *teaching and education* or *science and*

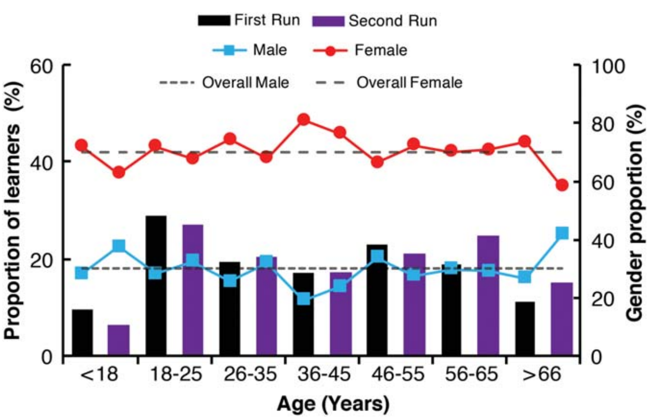

Figure 2.

Quantitative data received from the end of course survey to show learner age (years) from runs 1 (black) and 2 (purple) of the open phase. The left Y-axis represents the proportion of learners by age; the right Y-axis represents the proportion of learners by gender (male, blue squares; female, red circles) within each of the age ranges. The gender distribution for the whole course is also provided.

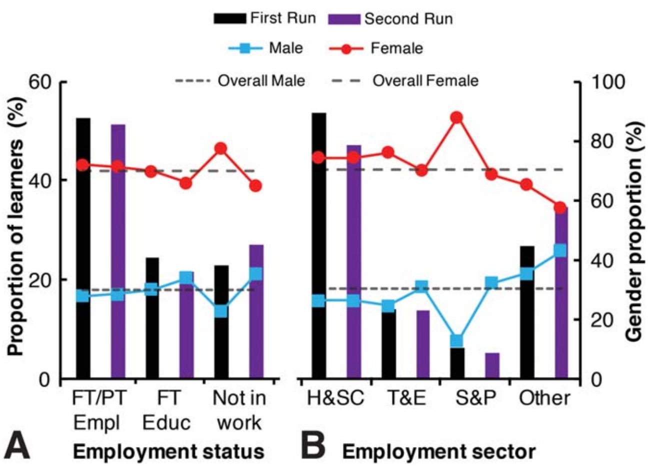

Figure 3.

Quantitative data received from the end of course survey to show: **A**, employment status and **B**, employment sector for learners from runs 1 (black) and 2 (purple) of the open phase. The left Y-axis represents the proportion of learners; the right Y-axis represents the proportion of learners by gender (male, blue squares; female, red circles) within each of the categories displayed. The gender distribution for the whole course is also provided. FT/PT Empl, full-time or part-time employment; FT Educ, full-time education; H&SC, health and social care; T&E, teaching and education; S&P, science and pharmaceuticals.

pharmaceutical sectors. However, run 2 did have a lower proportion of learners identifying with the *health and social care* sector which was concomitant with an increase in the number identifying with the *other* sectors provided compared with run 1. Although the *teaching and education*, and *science and pharmaceutical* sectors, were evenly matched for each run of the MOOC the distribution of learner employment sector varied significantly between the two runs of the course, χ^2 (5, $n = 601$) = 12.99, $P = 0.004$. Unlike employment status, the types of sectors in which the learners identified appeared to vary significantly in regard to gender (Fig. 3B) across run 1, χ^2 (2, $n = 266$) = 201.27, $P < 0.001$, run 2, χ^2 (3, $n = 435$) = 11.10, $P = 0.01$, and when both courses were combined, χ^2 (3, $n = 701$) = 14.28, $P = 0.002$. Particularly notable, was the gender breakdown for those learners identifying with the *science and pharmaceutical sector* where there was a much higher number of female learners for run 1. The gender breakdown was more equally distributed for the learners identifying with the *other* available sectors.

All learners were asked to provide information on their educational background ranging from less than secondary/high school through to a University Doctorate degree. Combining both runs of the course there were 39 (2.88%) learners with less than a secondary/high school education, 422 (31.21%) with secondary/high school education, 586 (43.34%) having a University degree, 239 (17.68%) having a University Masters degree, and 66 (4.88%) having a University Doctorate. Figure 4 shows the range of educational background for the two runs of the course and clearly reveals that the majority of learners on the course had either secondary/high school or a University degree. Learners with higher degrees (Masters and Doctorates) or without a secondary/high school education were not as prominent on either runs of the course. The distribution of education background varied significantly between the two runs of the course, χ^2 (4, $n = 1{,}352$) = 1,041.60, $P < 0.001$, with the highest proportion of learners having either a high school or a degree level of education. The gender distribution is also shown in Figure 4, and reveals a similar distribution of gender across both runs for those learners with less than a secondary/high school education, secondary/high school education, and degree level education. However, the proportion of male and female learners seemed to be more evenly matched for those learners who had a higher degree (Masters or Doctorate). The educational background of the learners varied with gender across run 1, χ^2 (4, $n = 514$) = 36.19, $P < 0.001$; run 2, χ^2 (4, $n = 838$) = 159.34, $P < 0.001$; and when both runs were combine, χ^2 (4, $n = 3{,}152$) = 570.38, $P < 0.001$.

Campus Phase

Enrolment on to the MOOC. There were 232 Year 1 medical students able to join the Anatomy MOOC during run 2 when the course was timed to coincide with the gastrointestinal and renal strands of the MBChB Body Systems module. From the Year 1 cohort 178 (76.7%) students completed the questionnaire. Of these students, 109 (61.2%) confirmed they enrolled on the course. Therefore, 47.0% of Year 1 MBChB students enrolled on to the MOOC. Within this 109, 34 (31.5%) identified as male, while 74 (68.5%) identified as female (one person withheld their gender). This distribution of gender across the enrolled students did not vary significantly from the gender split within the MBChB cohort as a whole [76 (32.3%), male; 159 (67.7%), female], χ^2 (1, $n = 343$) = 0.025, $P = 0.87$. Although the majority of students within the Leeds course are undergraduate students entering after secondary school (76.6%; or as mature students, 1.9%), there are also a number of students undertaking medicine as a second degree (21.5%).

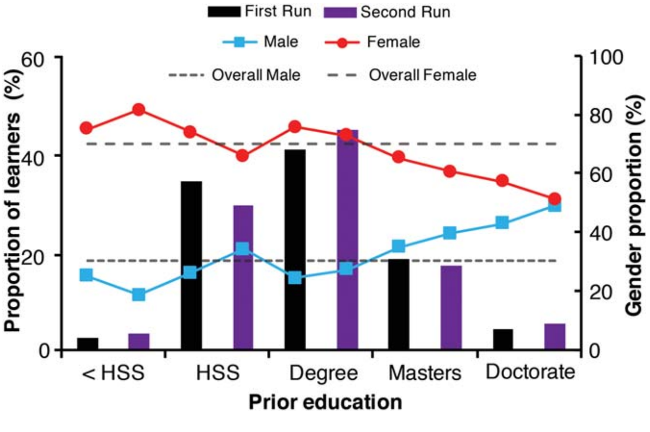

Figure 4.

Quantitative data received from the end of course survey to show prior education of learners from runs 1 (black) and 2 (purple) within the open phase. The left Y-axis represents the proportion of learners by prior education; the right Y-axis represents the proportion of learners by gender (male, blue squares; female, red circles) within each of education categories displayed. The gender distribution for the whole course is also provided. <HSS, less than high or secondary school; HSS, high or secondary school.

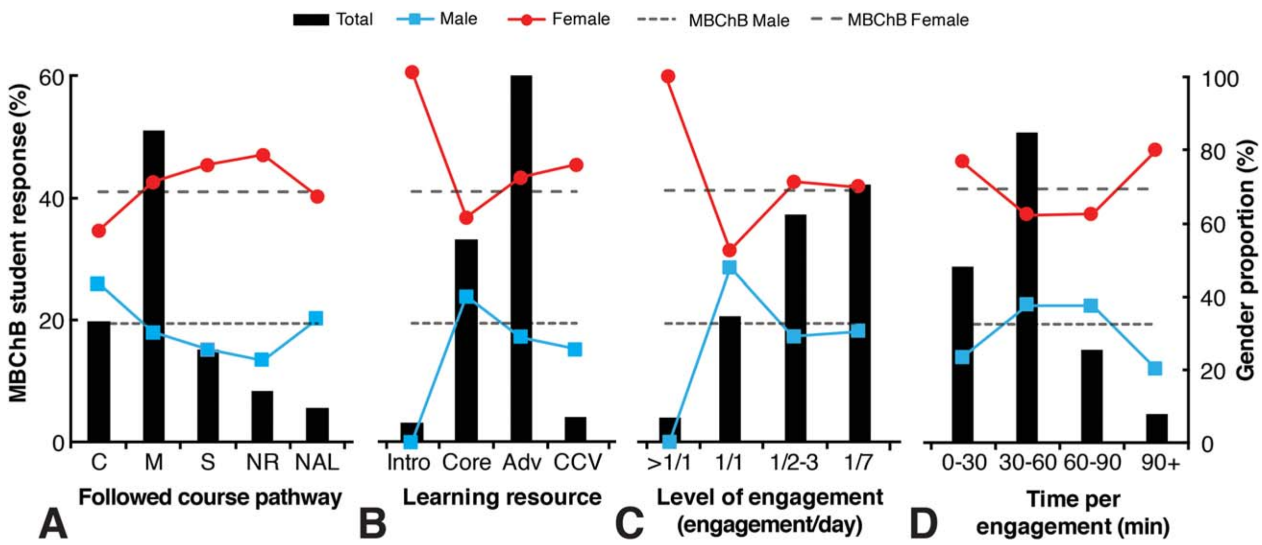

Figure 5.

Quantitative data received from the campus phase to show: **A**, the extent to which MBChB students followed the suggested course pathway; **B**, the preferred learning resource used; **C**, the level of engagement per day and **D**, the time (minutes) spent during each engagement per visit. The left Y-axis represents the proportion of students; with the right Y-axis representing this proportion by gender (male, blue squares; female, red circles) within each of categories displayed. The gender distribution for the whole cohort is also provided. C, completely; M, mostly; S, somewhat; NR, not really; NAL, not at all; Intro, introductory lectures; Core, core lectures; Adv, advanced lectures; CCV, clinical case videos.

Engagement with the MOOC. The degree of engagement with the MOOC by MBChB students was investigated via a self-reported questionnaire which was provided to the entire Year 1 cohort upon completion of the Body Systems course. Date presented are from the questionnaire which focused on the location and mode when accessing the MOOC, the level of interaction with the resources and whether they followed the path suggested by the course. The vast majority of students accessed the course at home, with only a minority of students engaging with the material on campus; an even smaller number of students accessed the material while travelling on a mobile device, such as a smart phone or Tablet device. Moreover, this relationship was consistent across gender despite a slight increase in the number of female students accessing the course on campus, χ^2 (2, $n = 108$) = 0.48, $P = 0.79$.

Although the resources embedded within the MOOC were freely accessible, a pathway was suggested to allow the students to interact with the course in a systematic way. Figure 5A reveals the extent to which the MBChB students followed this path with the majority (70.7%) following the prescribed course pathway either "completely" or "mostly." The remaining students followed the pathway to a lesser extent. The gender distribution is also detailed in Figure 5A and shows a deviation from the course gender balance; a more equal number of male and female students "completely" followed the course, while there was an increased proportion of female students who followed the course pathway to a lesser extent ("somewhat" and "not really"). However, this relationship did not differ significantly, χ^2 (4, $n = 106$) = 3.12, $P = 0.54$.

Within the MOOC the MBChB students engaged with the "advanced lectures" to a much greater extent than any of the other resources available (Fig. 5B); both the "introductory lectures" and "clinical case videos" were accessed minimally. Figure 5B reveals that no male students accessed the "introductory lectures," while the other learning resources were accessed by a proportion of male and female students which was representative of the gender balance across the course, χ^2 (1, $n = 99$) = 1.63, $P = 0.20$ (N.B. due to the low number of students who accessed the "introductory lectures" and "clinical case videos" these were excluded from the χ^2 analysis).

The students had unlimited access to the MOOC and could use it at a level that suited their own learning need. Figures 5C and 5D reveal the level of engagement on a daily basis, and how long the students engaged each time they accessed the MOOC. The majority of students engaged with the resource between once every two to three days to once a week (79.5%), with more frequent engagement being at a much lower level. The level of engagement did not differ significantly with gender which resembled the course distribution, χ^2 (3, $n = 104$) = 2.53, $P = 0.28$. With regard to the amount of time the students spent accessing course resources each time they accessed the course, the majority of students (79.8%) spent 0–60 minutes engaged each time (Fig. 5D). Similar to the daily level of engagement the gender balance for the time spent per visit did not differ significantly and resembled the course distribution, χ^2 (3, $n = 104$) = 1.97, $P = 0.37$ (N.B. due to the low number of students who accessed the course "more than once per day" and "90+ minutes" these were excluded from the χ^2 analysis).

Student feedback. To assess the impact of the MOOC on learning a number of positively phrased statements were presented on a five-point Likert scale, with a score toward five reporting agreement. Alongside the mean and standard deviation presented in Figures 6 and 7, the percentage of students who agreed (agree or strongly agree) is also provided within the following section (Boone and Boone, 2012). The questionnaire was divided into the two parts to measure the impact on learning and the perceived quality of the MOOC. The MBChB students agreed with four of the six questions relating to impact on learning with little difference being observed between male or female learners (Fig. 6). As a group they agreed that the content and objectives of the MOOC were appropriate for the Body Systems learning (97.2%), and that the tests interspersed throughout the course were useful in gauging their level of knowledge having engaged with the MOOC (85.7%). Similar findings were reported by both male (96.9% and 90.9%) and female (97.3% and 83.1%) learners, respectively, with the notable exception that female learners did not appear to appreciate the in course tests as much as their male peers. Furthermore, they agreed that the resources available within the MOOC were a good addition to what was already available (96.2%) and that overall the course had been useful in advancing their learning (94.4%). This was again consistent across gender with male (97.0% and 97.0%) and female (95.7% and 93.2%) learners responding similarly.

Two questions did not meet with uniform approval with these relating to *replacing their traditional learning of anatomy for the Body Systems course (lectures, tutorials, and dissection-based practical classes) with the* MOOC (17.5%) and their *active participation in the discussion and research questions sections* (7.3%). In regard to replacing the existing teaching with the MOOC male (16.1%) and female (18.3%) learners responded similarly, but only female students (10.7%) actively participated in the research and discussion questions.

The second section of the questionnaire consisted of three questions (Fig. 7), which addressed the perceived quality of the MOOC with the standard of the learning resources (91.6%) and the overall quality of the MOOC (98.1%) both being rated highly. Again this was consistent in regard to gender with male (93.8% and 100%) and female (90.5% and 97.3%) learners, respectively. The final statement relating to increasing the interest of anatomy having completed the MOOC scored much lower (overall, 70.1%; male, 72.7%; female, 68.5%).

Qualitative data was collected by two free-form sections in the questionnaire which required the students to detail the perceived strengths and weaknesses of the MOOC. In total 122 comments were received from 79 (72.5%) individual students who completed the course (30 learners did not provide a comment), with Table 3 detailing the number of comments received for each theme. Each theme was deemed to be a strength or weakness, with seven themes being identified. This was supported and enriched by the focus group commentary where students provided their opinions on various aspects of the MOOC which have subsequently been associated to a theme.

In regard to the videos used throughout the MOOC the students found these to be a strength with their design and duration being commended: *"The videos are not too long as well…perfect time, length of video so…toward the end you still have that interest and you don't lose focus"* [P1], "…*the videos—the maximum was…15 minutes—and if you didn't understand something you didn't have to trawl…like an hour [with a lecture recording] or more…to try and find…the thing you didn't understand, whereas the videos were a really good length, so you could just watch that, and if you wanted to watch it a few times you could, 'cos [sic] they weren't too long"* [P2] and *"I thought the videos were really good, especially when…Dr Pickering drew [screencasts] it all out, 'cos [sic] he does that in our lectures…so that was really helpful 'cos [sic] then you can draw along with it and pause the video"* [P2].

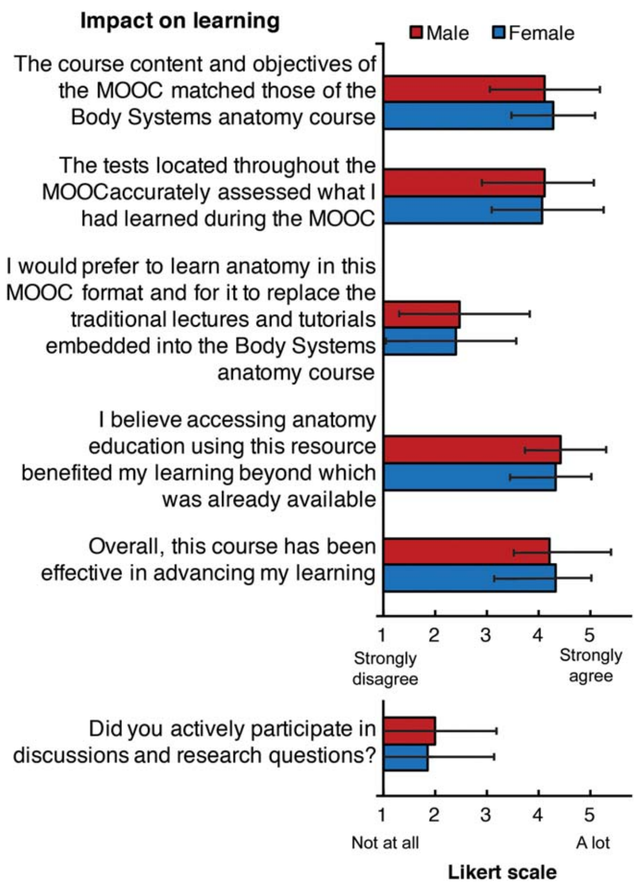

Figure 6.

Quantitative data for the impact of the massive open online course (MOOC) on the MBChB students. Data is presented as mean ± standard deviation of the mean. Likert scale for first five questions: 1 = strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree; 5 = strongly agree. Likert scale for the last question: 1 = not at all; 2 = not very much; 3 = some; 4 = quite a lot; 5 = a lot. Number of participants $n = 104–109$; Cronbach's alpha = 0.82.

The course design and its accessibility were both highlighted as strengths with comments, such as: *"Well it started off very basic, so it went from the basics into much more complex stuff which was really good"* [P1] and "…*you could do it whenever you wanted to, whereas if you're actually going to a lecture you have to be there when they say it is, and you've got to get there, whereas this you can just do whenever you want wherever you want"* [P3]. However, some students commented that they did not have enough time to complete the course as they had other commitments and there were already additional resources available "…*if I had more time I'd like to do it, but at that time I was doing Anatomy revision, so I…did the relevant bits"* [P1]. Moreover, additional information on how the platform could be navigated was raised: *"I thought it would have been good to know that we could go back (i.e., return to the previous screen's content) [All agreed]"* [P1].

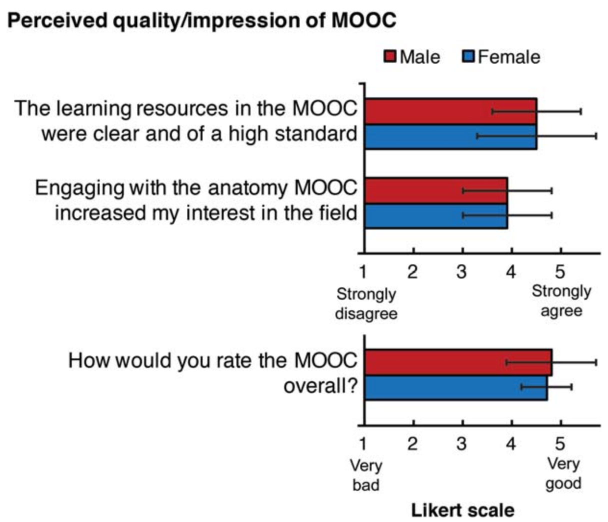

Figure 7.

Quantitative data for perceived quality and impression of the massive open online course (MOOC) on the MBChB students. Data is presented as mean ± standard deviation of the mean. Likert scale for first two questions: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree. Likert scale for the last question: 1 = very bad; 2 = bad; 3 = neutral; 4 = good; 5 = very good. Number of participants n =104–109; Cronbach's alpha = 0.82.

Students also provided some additional comments on the value of the comment and discussion boards with the lack of enthusiasm highlighted in Figure 6 coming through: *"[I used them] …a little bit but I didn't actually post anything myself"* [P1] and *"It was during the exam period so the last thing you want to do is comment"* [P4]. Furthermore, context was provided as to why the discussions board didn't form an important part of the course: *"I think as well we're in a year group of 240 people that [sic] are all doing the same thing, if you had a question about work, I'd just normally talk to my friends about it. Because as well…everybody doing the MOOC wasn't a medical student, so if I had quite a specific question about one of the advanced bits, they might not know whereas you can just ask one of your friends who's doing the same level as you"* [P2]. Although these discursive elements of the MOOC were not well received by the MBChB students, the online tests provided additional value: *"I think they go hand in hand with the content…so it's not something you wouldn't know from the videos…I think it was quite tailored"* [P4] and *"there was quite a good mix of questions for a range of abilities and people with different experiences"* [P4].

The students provided a number of generally positive comments in relation to their overall impression of the course: *"I thought it was really good"* [P1], *"I just thought it was another way of explaining things that quite often help me to understand it"* [P3] and *"I thought it was quite well organised…which helped, and you could test yourself at every opportunity, whereas You Tube videos don't have that"* [P1]. They also commented on its use alongside the existing teaching, highlighting an important role in supplementing their studies, but not to replace: *"I personally used it to supplement the lectures…I wouldn't like it to replace lectures"* [P3] and *"It was good to be able to see…pictures where it was clear with everything how it was meant to be…it can be quite hard to see on a cadaver but because our spot tests were obviously using a cadaver, I did find it helpful"* [P3].

Table 3.

Summary of Qualitative Feedback Received From the MBChB Student Questionnaire Including the Strength and Weakness Themes and the Number of Comments for Each

Strengths		Weaknesses	
Themes	**Number of comments *n***	**Themes**	**Number of comments *n***
Advanced videos (screencasts)/ Clinical videos	17/3	Already had enough resources/ something else to integrate into revision	19/2
Continual engagement with material/revision/consolidation	13	Prefer the cadaver/prosection/ existing teaching	8
Logical progression/course layout	6	Not enough time to complete the course	7
Quality of videos	6	Too basic content/not enough detail/not all relevant material	6/3/1
Accessibility	5	Not to replace current teaching	4
Online tests	4	MCQs were too easy/more MCQs	3
Different style of learning (platform)	3	Hard to follow online compared with lecture series/Design of platform (videos on one page)	3/3

Students comments were aggregated into themes; MCQs, multiple choice questions.

Moreover, as a teaching resource it seemed to be well received, but within the context of the Body Systems course it only has a limited role: "*I think it would be enough, but I don't think I'd feel as confident*" [P3].

DISCUSSION

Since the concept of MOOCs was first established nearly a decade ago many commercial providers have established platforms to host mainly university-level courses, with almost 700 MOOCs being delivered to more than eight million users worldwide (Perna et al., 2014). Due to this upsurge in available online courses that are easily accessed many commentators have suggested that MOOCs could be a real educational game-changer especially in the field of medical, and in the context of this study, anatomical education (Prober and Heath, 2012; Harder, 2013; Prober and Khan, 2013; Sharma et al., 2014). In light of this developing area of education, this study embarked on investigating the impact of an anatomy MOOC delivered by the University of Leeds, United Kingdom, on two distinct audiences. The first part of the study, the open phase, analysed the demographic data from two runs of the anatomy MOOC to investigate the general public's uptake and engagement with a science based course, specifically focusing on one area of the human body. The second part, the campus phase, explored how campus-based medical students currently studying anatomy at the host institution's medical school would use the MOOC as part of their year 1 curriculum.

Public Engagement with the Anatomy MOOC

For both runs of the course a similar number of enrolments were registered, but as is typical with MOOCs the actual number of learners who then actively participated in the course dropped away (Morris et al., 2015), with only approximately 40%–50% of the learners going on to actively engage with the resources available (Table 2). It is these learners who actively engaged in a minimum of two steps and then completed a pre-course survey who provide the demographic data for the course. This means, however, that the results presented are only representative of these learners, who would be considered particularly enthusiastic as they both engaged in the course and spent time completing the survey. This is less than ideal and therefore the results should generally be treated with caution. However, the general demographic data illustrated in the open phase of the study is sufficiently consistent to the wider MOOC literature that it can therefore be considered a valuable addition.

As can be observed from the demographics provided there was a wide range of learners with varying age, employment status and employment sector profiles, with the majority of learners being between 18 and 25 years of age, employed within the health and social care sector and already holding a degree level qualification. This indicates a specialized group of learners who preferentially engaged with the course and supports the planned targeting of healthcare workers when the course was being developed. Whether this was specifically attributable to the marketing campaign is unclear.

Further analysis of the demographic data reveals that the vast majority of learners were female, which has been observed in some of the other MOOCs delivered by the University (Morris et al., 2015) and matches the increased proportion of female users who are registered with FutureLearn (2015). However, this is not necessarily consistent with other courses (Breslow et al., 2013; Kizilcec et al., 2013), with there not, as yet, being a defined MOOC learner profile (Perna et al., 2014). Exploring the distribution across the various demographic profiles which were assessed indicates a consistent distribution of gender across both age and employment status. However, for both employment sector and educational background the distribution seems to deviate. Although the literature is mixed on the distribution of gender on MOOC engagement, the high number of female learners registered and actively engaged in the anatomy MOOC may be due to the high number of learners who associated with the health and social care employment sector (Fig. 3B), with this area of employment being highly populated with females (Yar et al., 2006). Therefore, it could be that this group of learners specifically targeted the MOOC out of general subject interest or to specifically learn more about the area to enhance their own practice.

The range of prior educational attainment also deviated at the higher level, with the proportion of male and female learners becoming more equal (Fig. 4). Given the gender distribution across the MOOC, there appears to be an indication that male learners were more qualified than female. This finding may not appear too surprising given there is an imbalance in school and university age learners undertaking science based courses within the United Kingdom (WISE, 2014). Generally, the learners who engaged with the MOOC were highly qualified with the majority having at least a university degree level of qualification and this again is consistent with other MOOCs (Christensen et al., 2013; Goldberg et al., 2015; Hansen and Reich, 2015).

What is clear from the demographic data presented is that the course was unable to attract a significant population of pre-university learners, although the average age was lower than most MOOCs (Morris et al., 2015). This conclusion is supported by the observed age range, with a clear minority of learners confirming they were less than 18 years of age (Fig. 2); the anticipated age range for the pre-university group. Reasons for the lack of uptake is unclear, with the integration of MOOCs into this level of education potentially having some clear benefits (Sharron, 2014; Chung, 2015). Furthermore, a sensible approach to introducing MOOCs in to the school curriculum would be for them to be integrated into existing subjects and this would rely on greater communication between the host university and the local schools. Since the number of learners who associated with the teaching and education employment sector was low, it would appear that this would need to be a targeted initiative and a strategic priority for the course as it appears unlikely to occur surreptitiously.

The successful targeting of current undergraduate students to the MOOC appears to have been of limited success. The demographic data supports a number of learners who were in the age range of 18–25 (Fig. 2), associated with full-time education as their employment status (Fig. 3B) and had previously completed high or secondary school education (Fig. 4). What is not clear however is how many of these students were enrolled on a course that required anatomy, such as a medical or dental, with it being possible that a range of undergraduate students may have engaged with the MOOC out of general interest. Although the data suggests a proportion of learners were undergraduate students it is difficult to be certain as many of the 18–25 years of age learners may in fact have been employed in the health and social care sector, which had a much high proportion of learners. This would make sense as a number of entry level positions within the health and social care sector can be obtained with either existing secondary or high school, or in-work, qualifications (SkillsforCare, 2015). Due to the potential benefit undergraduate students may receive by either integrating the whole or parts of a MOOC in to their existing course, this area was studied within the campus-phase of the study which is discussed below.

Campus-Based Students' Use of the Anatomy MOOC

The campus phase of the study assessed the impact of the anatomy MOOC specifically on year 1 undergraduate medical students at the University of Leeds' medical school. The use of TEL resources to support medical and particularly anatomical education is developing rapidly to alleviate well-known curricula issues (Heylings, 2002; Sugand et al., 2010). Therefore, due to the increased popularity of MOOCs within higher education and their potential for supporting the delivery of curricula it is timely to assess their impact on supporting medical students undertaking anatomy education as part their course. Many commentators have suggested a potential role for MOOCs to replace or significantly influence the traditional approach to university teaching (Prober and Heath, 2012; Prober and Khan, 2013; Harder, 2013; Sharma et al., 2014), however, as of yet these ideas have not fully materialized.

Despite the web-based and mobile nature of the FutureLearn platform the vast majority of students engaged with the MOOC in their own accommodation, with only a small proportion engaging either on campus or while commuting with a mobile device. This finding is not particularly surprising as the majority of students live within a one to two mile radius of campus, and it could be proposed that they would be commuting with fellow students at this time. Having spent a full day on campus the inclination to continue learning on site is probably low. Moreover, having a congested timetable the opportunity to engage with the MOOC while on campus may also be reduced, although some students do prefer to work in the campus library and this may account for the proportion of students who associated with this location of access. In regard to the students' engagement with the MOOC the data suggests they did so in a meaningful and constructive way, with evidence to support separation of approach according to gender. Generally, it appears that a higher proportion of female learners personalized their learning compared with males. This can be observed in Figure 5A where a greater proportion of females, in comparison to males, worked through the course without following the suggested pathway. Moreover, it also appears that a higher proportion of male students engaged with the core lectures, compared with the females who accessed the advanced material in higher numbers (Fig. 5B). This is a particularly interesting finding as the core lectures covered a lot of material which was specifically covered in the existing Body Systems teaching with the advanced material allowing the students to extend their learning for consolidation and revision. From this distribution of engagement, it appears that the female learners engaged with the MOOC in a much more personalized way. Effectively, they accessed and engaged in only those resources that were key to furthering their learning; in comparison, the male learners seemed to engage in the course in a more ordered way, accessing resources that were also delivered as part of the teacher-led sessions and treating the course as a complete program that had to be worked through.

The level of engagement with regard to days during the week and time spent per visit (Figs. 5C and 5D) were fairly consistent for both male and female students, with the majority engaging a few times a week and for approximately an hour each time. This level of engagement can be considered to be relatively high if viewed as part of the whole year 1 curriculum which includes a number of other modules running concomitantly with Body Systems.

The suggestion that the MOOC was used in a personalized way is further reinforced by the use of the discussion fora and online quizzes. While the discussion fora were not heavily engaged with, the online quizzes appeared to be much valued by the students. Other research has suggested that the use of discussion fora within MOOCs that have been integrated in to campus based teaching are used very little with students preferring to engage with their local community rather than the online learners (Bruff et al., 2013). Furthermore, the vastness of discussion fora within MOOCs has also been suggested as a reason why undergraduate students are sometimes deterred from entering in to this virtual space (Baggaley, 2013). The approach to discussion fora is likely to be very different if you are not based on a campus with this learning opportunity being the only opportunity they would have to ask questions, and have them answered by the MOOC team or a fellow learner. Although the students did not seem overly concerned by the magnitude of the discussion fora their main reason for not engaging was the availability of their fellow students and members of faculty to answer any problems they had. This limited use of the discussion fora was clearly evident from the questionnaire and focus groups session (Fig. 6), although they did clearly appreciate their overall value for other learners. The use of discussion fora has been used in anatomical education before with some degree of success with these being administered by the institution's own teaching staff and in this setting the students may feel more confident in posting questions (Choudhury et al., 2010; Green et al., 2014). Moreover, the development of small private online course (SPOCs) may solve the problems of vastness and promote more interaction between campus based students. Although the discussion fora seem to be of limited use to campus based students the online quizzes appeared to be popular with the student group at Leeds and elsewhere (Bruff et al., 2013). These were often used in order to monitor their own progress and ensure they were on the right track.

The general idea of MOOCs being used within an existing course, or as an alternative approach to education delivery has the potential to allow for greater flexibility. However, although there are clear opportunities for the increased use of MOOCs in anatomical, and the wider medical education area, their adoption needs to be carefully considered. While similar studies have indicated a generally positive impact on campus-based students who had a MOOC integrated into their existing course (Ghadiri et al., 2013; Griffiths et al., 2014; Kearney et al., 2016), it is important the students are clear what they need to know and that the content provided by the external MOOC is appropriate (Bruff et al., 2013). Although there is a clear advantage in integrating the host institutions MOOC into the existing teaching for the campus based students, it is not financially or temporally feasible for this approach to be used everywhere, and in fact is not the primary driver for developing MOOCs. However, as can been seen from the feedback for the anatomy MOOC at Leeds the students rated highly the teaching resources, found them to be a worthwhile addition to their learning and that they were appropriate for their course. This is not surprising, but it does support the idea that if a MOOC is going to be integrated in to a course the learning objectives and academic level of the course needs to be appropriate.

It is interesting to observe that although the students appeared to value the MOOC's content, rather than its *massiveness*, they had no desire for the MOOC to replace the existing teaching that was already provided as part of their course. Similarly, other studies have found that the resources provided by MOOCs are greatly appreciated by the campus based students, but they also highly value the time spent with the teaching staff (Bruff et al., 2013; Griffiths et al., 2014). In essence it appears that the students were highly appreciative of this resource in regard to having high quality teaching resources available to them in an easily accessible format. They were able to enter the course freely and interact with it as they wished without any specific requirements for engagement or completion. However, the *massive* and *open* features did not necessarily appeal. The online nature of the resources is clearly an advantage for students, with the increased accessibility this approach to education can offer. Furthermore, similar to other studies there also appears to be significant evidence that this approach to education allows personalization of learning to occur, especially among the female learners (Adams and Yin, 2014). However, although the students were generally appreciative of the additional support provided the vast majority of students did not want this learning approach to replace the existing teaching that was already provided and some of them indicated that if this was used on its own they would have reduced confidence when it comes to examinations. Moreover, several of the students commented that having this additional resource placed an extra load onto their already busy schedules even though the MOOC was presented as being voluntary.

In light of the findings presented the integration of an anatomy MOOC into the existing curriculum appears to be mixed. Students generally enjoyed accessing the resources and appeared to benefit from them, but whether they needed to be delivered via a MOOC platform is still unclear given that they disregarded the *open* and *massive* nature. Due to the suggestion that MOOCs, or their content can form a greater part of medical education, possibly in the format of flipped classrooms this research is particularly interesting. As has been shown the students enjoyed the resources, but they also valued the existing time with the teaching staff and did not want the current teaching provided to be replaced. This would indicate that the complete replacement of campus-based teaching with MOOCs is not ideal, but the opportunity to take content from existing MOOCs either those developed internally or from outside institutions is persuasive as long as the curriculum is suitably aligned and the resources provided are appropriate and do not put an increased workload on to the students. The use of online resources to support anatomical education is popular but consideration must be given to when students are expected to access this material alongside the other course requirements.

Study Limitations and Future Directions

The limitations of the open phase of the study are the small sample size in relation to the number of enrolments and the fact that the learners who completed the post-course survey are probably not truly representative of the entire cohort. Therefore, although the majority of the findings can be accounted for they should be treated with a certain degree of caution.

In regard to the campus phase of the study the main limitation is the inability to assess the individual engagement with the resource in two aspects. Firstly, being able to monitor the actual student usage on the platform rather than asking them via a questionnaire when they may provide more general information on their perceived usage. This degree of analysis was not possible due to the unique tagging system used on the FutureLearn platform. Secondly, as the focus group was small a wider and more diverse appraisal of the MOOC and how it impacted on their learning was not possible.

Future research will continue to assess the integration of MOOCs into undergraduate anatomy curricula in regard to the personalization element of learning via a MOOC. Specifically, looking at how this separates in regard to gender, academic ability, prior education background and age. Moreover, it will also be pertinent to assess how MOOCs are used by different groups of learners, some of which will not have the same level of anatomy teaching as that provided for the Leeds medical students. For example, campus-based biomedical science students who need to have an understanding of anatomy as part of their course but do not receive as much teacher-led anatomy teaching as medical students, or graduate students who are no longer based on campus but may still require to engage with anatomy resources for continuing development. These groups may interact with the course in a different way. In light of the findings presented here there is clear scope for further research into the impact MOOCs have on anatomical and medical education.

CONCLUSIONS

A three-week anatomy MOOC was developed by the School of Medicine at the University of Leeds, United Kingdom, and run twice with the second delivery of the course timed to coincide with the abdominal anatomy part of their MBChB course. Generally, the course appeared to be well received by the general public with a clear suggestion that healthcare workers appeared to be a significant cohort of engaged learners, with the possibility that current undergraduate students also formed a significant proportion. In regard to meeting the intended target audience during the development of the course this was a positive, although the third group, pre-university learners, did not materialize in any substantial proportion.

In regard to the campus phase of the study the medical students appeared to engage with the MOOC's content, specifically the core and advanced videos, and the quizzes, but failed to engage heavily with the discussion fora which were available. There also appeared to be a level of personalization, particularly amongst the female learners. Further work on the value of integrating MOOCs in to campus-based curricula for a variety of demographics and courses is still required.

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