A study of user participation across different delivery modes of a Massive Open Online Course

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Abstract: Massive Open Online Courses (MOOCs) are offered by many universities, with hundreds of thousands of people worldwide having registered for one or more of the many available courses. Despite the potential that has been claimed for these courses to transform education, in practice the majority are deeply conservative in maintaining the educational status quo. Lacking innovative pedagogic foundation and with the need for approaches that scale, many courses rely heavily on very traditional methods such as mini-lectures and quizzes. In particular, learner support is proving to be insufficient for many participants. This paper reports results and experience from developing and presenting a MOOC which provides both "traditional" and supported modes. Users can opt to study the course in the way familiar within most MOOCs (with peer support and limited tutor input) or to receive a high level of experienced tutor support. Having both modes run in parallel allows direct comparison between the experiences and achievements of the two groups. We present the motivation and objectives for the course, discuss results obtained and reflect on lessons learned in the process.

Keywords: Massive Open Online Course; MOOC; course evaluation; online learning; pedagogy

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1 Introduction

Massive Open Online Courses (MOOCs) have received a great deal of publicity in recent years with top universities competing to provide free online courses for all via platforms such as Coursera [10] and edX [13]. Many claims have been made about the benefits of such courses and the way in which they might provide solutions to a range of educational challenges such as reducing costs, increasing numbers, widening participation to learners that would not previously have had the opportunity to engage and breaking down geographical boundaries.

The term “MOOC” was originally coined to describe a connectivist approach to learning in which each participant sets their own learning goals and works, through social interaction and the development of digital artefacts, to generate knowledge in a network [31, 9]. The 2008 course, “Connectivism and Connective Knowledge” (CCK08) provided an early example of a connectivist MOOC (or cMOOC) [29] using this approach. The term is now used more broadly, encompassing widely differing perspectives on learning theory, pedagogy, support and even the meaning of the basic terms “massive”, “open” and “course” [4]. The predominant model has become the Coursera/edX type course (or xMOOC) [35, 11] with a recognisable pattern of learning resources, quizzes, forums and (sometimes) peer assessment. These and similar platform providers have signed up rapidly increasing numbers of university partners [28, 10] and are now offering hundreds of courses free of charge to anyone who wishes to sign up. Many universities have invested substantially in providing this type of MOOC [47] despite a lack of evidence as to their effectiveness, concerns over what purposes they do (and indeed can) fulfil, and a dearth of knowledge on suitable pedagogy [4].

Large amounts of data are now being collected by many platforms (although in a lot of cases this is not made publically available). Application of learning analytics techniques is now producing useful results such as an increasingly accurate ability to predict which learners are in danger of dropping out and at what stage this is likely to happen [39]. However, there is still little understanding of the users’ experience in this and of the strategies that can prove effective in preventing such attrition. At the most basic level we might ask whether large scale courses with little tutor support are really capable of helping any but the most able and effective independent learners, and if so, how the learning opportunities can be maximised by appropriate yet scalable pedagogy.

This paper reports results from a study in which a MOOC was presented in two separate, simultaneous modes. The first mode followed a “standard” approach, with all materials freely accessible and support provided via forums incorporating both peer support and tutor support. Students opting for the second approach had access to all these facilities and resources but in addition they were able to access a high level of tutor support via regular real-time tutorial sessions and a dedicated tutor-monitored forum. For the second mode a (modest) payment was required. Engagement and achievements of students on each mode can thus be directly compared.

The course studied was designed as Continuing Professional Development for teachers preparing to deliver the new Computing Curriculum in UK schools. Although participation was mainly from UK teachers it was not restricted to this group. The background for the course is explained further below. The MOOC is now in its second delivery. In a previous paper [38] we reported on initial results gathered from the first two session of the first delivery of the MOOC. The current paper completes the picture by presenting and reflecting upon data gathered from the whole of the first full run.

The paper is organised as follows. Section 2 presents a literature review relating to the learning experience in MOOCs. We examine specifically the different levels of learner support offered and, correspondingly, the learner perspective on the adequacy of the support available. Sections 3 and 4 provide information on the background of the MOOC and the decisions taken in the development of this online course. Quantitative results obtained from the first run of the course are given in Section 5 with Section 6 presenting some aspects of the feedback obtained from the end of session evaluations. A discussion of the results obtained and reflection on the process and achievements is contained in Section 6. Conclusions are presented in Section 7.

2 Literature review

The rapid rise of the MOOC has been driven by high expectations of what they can achieve. It has been suggested that these courses will greatly reduce tuition costs by reducing teaching staff levels [47]; that they can democratise education by making high class tuition freely available for all [27]; that they can solve educational needs for developing countries by removing monetary and geographical limitations [23]; that they represent a disruptive educational technology which can challenge and reshape existing norms [48] and that they "challenge universities' conventional societal role as purveyors of knowledge and credentials" [42].

Despite the envisaged potential for disruption and transformation of higher education, the majority of courses at the moment follow a fairly typical xMOOC model. Although there are differences between platforms, these large courses generally feature pre-recorded video lectures or mini presentations from subject experts, with quizzes (or other automated assessment), forum discussions and (sometimes) peer assessment. Material is often derived from courses taught in the university, as in, for example, the Software Engineering MOOC from Berkeley [15]. At one level, this is seen as a major benefit (since anyone, anywhere can now access modules similar to those studied by students enrolled at the university). However, such modules offer little flexibility to anyone who is not fully fluent in the digital literacies and independent learning skills required or who simply finds themself unable to cope with the pace and lack of support. This dissemination of pre-packaged, standardised fare is referred to by Lane and Kinser as the "MacDonaldization of Higher Education" [26]. Students who do succeed in their course are likely to find their reward is a MOOC certificate rather than an award of university level credits [3].

In recognition of the limitations, initiatives are emerging to address aspects of pedagogy and adaptivity. The "E-learning and Digital Cultures" MOOC from the University of Edinburgh was delivered on the Coursera platform but is noted for its tutor presence through live video conferencing [22]. Other work has attempted to account for different learning styles [18]. A more recent platform, NovoED [33] aims to support online courses with greater interaction. Supported by a number of major universities such as Stanford, NovoED incorporates real time feedback from learning analytics and aims to provide a social and collaborative experience.

Learning analytics provides a powerful predictive tool which can accurately identify students in danger of dropping out [1]. However, the question still remains as to what, in practice, can be done to assist students in danger and to support them in continuing with the course. This is an area of active research, the challenge being to find effective pedagogy and technical support which allows the limited staff effort combined with some model of peer support to be harnessed for maximum impact. Ross et al [36] consider the way that teachers are represented within MOOCs, noting that the this important role has been characterised in an unhelpful and limited way. Deconstructing the notion of "teacher as celebrity professor" helps to provide a more subtle focus on important aspects such as professional values and academic identity. It is also the case that effective teaching is about on-going, situation-specific guidance rather than star performances.

The issue of student support is a crucial one for the success of the MOOC enterprise. It represents a major difference between merely pushing out packaged learning materials and being able to offer a real educational service to individual learners. Within standard xMOOCs, there is evidence that existing models are insufficient to deliver this support. As a participant of Harvard's CS50X Computer Programming course put it: "Too few helpful students, and the questions of the confused majority will not be answered quickly enough, and the faculty are too outnumbered by the 100,000 students to keep up" [21]. The completion rate was 0.9%. Although many people who register for a MOOC generally do not even start the course, high drop-out rates may, in part, be related to the fact that there are not enough participants who feel confident with the course material to answer questions in peer support forums.

The problem of high dropout rates in MOOCs is noted by nearly everyone who writes about them. Clow [6] refers to a "funnel of participation" narrowing from relatively large initial awareness to relatively small progress in the course. In a recent paper about learner motivation, Davis et al [46] state: "What is not known is the extent of the participants' satisfaction with their (perhaps very limited) participation". While it is true that this is less easy to discover from learning analytics and has not provided a major focus of research, there is a good deal of evidence from learner blogs and elsewhere to suggest that many learners are *not* happy with their progress and feel they were not enable to proceed further. A recent study by Zheng et al. [49] examines reasons for learner drop-out from the students' perspective. The authors confirm the view that one of the major reasons for failure to complete is inadequate support, stating that learners "were unable to receive feedback from peers or teaching staff as the course progressed".

Lack of support is frustrating to students in courses taken as a spare time activity for those with interest and self-motivated learning skills (sometimes referred to as "edutainment"). It becomes critical when the role of a MOOC is taken beyond that of the "take it or leave it" learning resource. For example, a program introduced by San Jose State University and Udacity to run remedial courses in popular subjects ended in a failure rate of up to 71% [12]. Yet there is an indication that introductory and remedial classes with large enrolments are being perceived as particularly suitable for MOOC treatment [14]. In reality, students with remedial needs or those who just beginning their independent learning journey may not be equipped with the skills necessary to thrive in a MOOC.

There have been a number of initiatives to provide a more learner-focussed model of support. Vihavainen et al. [45] report on a programming MOOC in which a high level of support was provided by on-campus degree students. In a framework the authors call "Extreme Apprentice", the students providing tutor support were given credits towards their own degree for the work on the MOOC. Over 16% of students who registered completed at least 90% of the course tasks.

Veletsianos, Collier and Schneider [44] consider the importance for learning of social interaction both inside and outside a MOOC. Learners found external social interaction meaningful and, while there is no direct evidence that learning was increased, social communication helped foster a sense of community. The addition of an integrated note-taking application could allow notes to be shared with others and persist across and between different courses.

Some research, although not specifically directed at learner support, considers strategies which might increase participants' learning. For example, improving MOOC users' capacity for self-regulated learning and connecting content to real-world contexts are both suggested approaches [19].

MOOCs can also be used as part of a more traditional tutored class such as a "flipped classroom" where students learn the basics from online presentations and use the face-to-face sessions to provide instructor input for problem solving and discussion [5, 25, 37]. This model of MOOC is about using staff time more beneficially rather than trying to provide education with one instructor per 50,000 students [47].

Whatever method of support is chosen, it needs to be scalable and sustainable. Most universities have a great resource in terms of their PhD students who are often very experienced in helping out with on-campus undergraduate teaching. The "Extreme Apprentice" model of tuition-for-credit is appealing but does not transfer to PhD students who do not have credit-based assessment or to institutions in which regulations may not allow it.

Making comparisons across different MOOCs or even different runs of the same course can be problematic because of the large number of potential variations and differences. Colvin et al [7] report the findings of a study which investigated the learning outcomes of different groups of students on an introductory Newtonian Mechanics MOOC using a "concept inventory" pre- and post-test approach. They also compared these learning gains to those of on-campus students studying similar material. This work shows some interesting results about students who are progressing through the course. The fact that on-campus and MOOC results were similar supports the theory that successful MOOC takers are generally highly motivated and capable independent learners. However, it sheds no light on those students who fail to progress.

Our study investigates the achievements of two cohorts within a single MOOC. Members of both groups have similar background, motivation and circumstances. The groups are distinguished by the level of support offered throughout the course. We track the engagement and achievement of both groups throughout the delivery of the course and discuss issues related to the development of the MOOC and the take-up of support offered.

3 The Computing for Teachers MOOC: context

In September 2014 a new computing curriculum was introduced in UK schools. Computing is now a required subject for all children both in primary and secondary schools. Previously, many schools taught IT skills only. Despite the changes, there has been no formal, central initiative to train the teachers who will be required to teach the new curriculum. The University of Warwick (as part of the Network of Excellence organised by the UK's Computing at Schools organisation [8]) runs face to face activities and continuing professional development (CPD) sessions for teachers. This reaches a limited number of participants and is geographically restrictive. Supported in part by an award from Google's Computer Science for High Schools program, members of the Computer Science Department at the University of Warwick built on their experience of delivering on-campus CPD courses to develop a MOOC primarily aimed at UK teachers. In practice, registration was open to all so there has been a small number of non-teacher and non-UK participants. The course is aimed at teachers with no previous computing experience and provides preparation for teaching at a UK school KS4 level (ages 14 to 16). This was chosen as a critical key stage at which students will be preparing for public examinations. Course content was based on the UK Teaching Agency's requirements for trainee computer science teachers [43]. There are three basic concerns for teachers approaching the subject.

- **Computing concepts** Areas of knowledge needed, covered at appropriate level.
- **Programming** Text based language suitable for KS4 assignments.
- **Teaching issues** Addressing issues of how to teach computing in the classroom.

The MOOC was designed to incorporate three strands relating to these aspects. The "Concepts" strand covered material relating to the Teaching Agency document; the "Programming" strand introduced practical programming in Python with lots of practical exercises and hands-on tasks; the "Teaching" strand made use of teachers' expertise to create resources on pedagogy and lesson planning.

The first run of the Computing for Teachers (CfT) MOOC started in October 2013. It was structured as an initial introductory session followed by eight main teaching sessions which were spaced 2 weeks apart with an additional break over Christmas. The introduction gave an overview of the course, helped participants find their way in the online learning environment and ensured everyone had a suitable programming environment to work with before the main work of the course began. Previous discussion with teachers had indicated that fortnightly release of materials was the most appropriate timing as it allowed enough time for busy professionals to engage with the materials and attempt the exercises without leaving it too long and risking loss of momentum.

The CfT MOOC is different to many in that it is aimed at a specific group of learners and targeted towards CPD for a particular purpose. Teachers might be supposed to be a group who are highly effective independent learners and thus are able to manage their learning in the context of a MOOC. Given that the participants would soon be expected to teach computing, it also seemed reasonable to suppose that they would have a reasonable level of digital skills (although not necessarily be familiar with the specific technologies used in the course). Further, since many of the participants needed to develop the knowledge and skills in order to start teaching the topics themselves, it might also be supposed that their motivation to complete the course would be high. It might also be the case that an identified community with similar professional interests would find it easier to form learning communities and to become active in peer support through the peer support forums.

4 The Computing for Teachers MOOC: development

This section outlines some of the design and development issues faced.

4.1 Platform and programming language

Choice of platform influences what is provided and so, to some degree, the pedagogy and approach adopted. The University of Warwick is a partner in the Future Learn initiative (developed by the UK's Open University) [16]. However, at the time the CfT MOOC was being developed Future Learn was still at an early stage. It was therefore decided to use the learning environment, Moodle [32] as a framework for organising materials. Moodle is a VLE rather than a MOOC platform but local expertise was available to help create an environment adapted to our needs.

Although it would be possible to host videos locally, it was decided to use a hosting service to take care of this since several straight-forward and low cost options are available. This eased the burden on local development staff slightly. For the real-time programming labs, Google Hangouts [17] were used, providing support for voice, video, text and screen communication.

The language taught was Python, chosen as an accessible but powerful text-based programming language. Introductory videos clearly explained how to install Python on different operating systems. Information on different development environments was also provided. However, in order to make the barrier to getting started as low as possible we provided a web-based environment using Skulpt [40] which provides immediate type-and-run functionality without the need for installation of any kind.

4.2 Different modes

The MOOC was offered in two different modes.
Traditional All materials were made freely available to participants. Peer support was provided through forums, with some intervention from tutors. Progress was assessed using quizzes (for both programming and computing concepts). Participants will receive a certificate with a record of their achievement at the end of the course.
Supported Payment of £100 was required for this mode. In addition to the above, participants were assigned to small tutor-led groups which met using

Google hangouts twice a week throughout the course. Here, learners could receive immediate help and instruction from experienced PhD/post-doctoral tutors. Session were based around the lab session exercises appropriate to that session, but participants were able to get answers to questions on any aspect of Python programming or of the computing concepts covered in the course. An additional forum was also provided for the supported group. This had a guaranteed tutor response within 24 hours. Students on this mode also undertook a final programming task at the end of the course to bring together all they had learned. This was marked by course staff and individual feedback was provided. A separate certificate was awarded to indicate the level of achievement on this assignment.
Finally, a post-course workshop was held. This was scheduled in conjunction with the UK national "Computing at School" teachers' conference and provided the opportunity for members of the course to meet us and each other. It also allowed them to participate in a further group learning experience (this time relating to computer hardware and Little Man computing).

The two modes allowed learners to opt for the level of support they felt was appropriate to them. For research purposes, it also allows evaluation of students' achievement and experience on each mode and a direct comparison between them.

4.3 Resources provided

The following were made available for each main teaching session.

- **Computing concepts** video, slides, quiz.
- **Programming** video, slides, quiz, programming exercise sheets (known as "lab sessions") and solutions.
- **Teaching issues** video or audio recording from teachers or support organisation.

Additional exercises and solutions were made available where appropriate. Forums and links to further resources were also provided. We had not originally planned to provide transcripts of videos but, following a request from a hearing-impaired student the process of transcription was begun (although this remains to be completed).

5 Results

The results presented here are from the first delivery of the course which concluded in March 2014. Data was collected both through Moodle's own logging system and via our own evaluation forms completed by participants at the start of the course and after every session.

5.1 Registration

Registration for the tutor-supported group was allowed up to the launch of session 2. As participants would be working in small, on-line real-time tutor groups we wanted to keep them together in terms of their pacing in working through the

	Registrations	Never logged in
Traditional	618	73
Supported	30	0
Total	648	73

Figure 1 Registrations on the two different modes of the MOOC

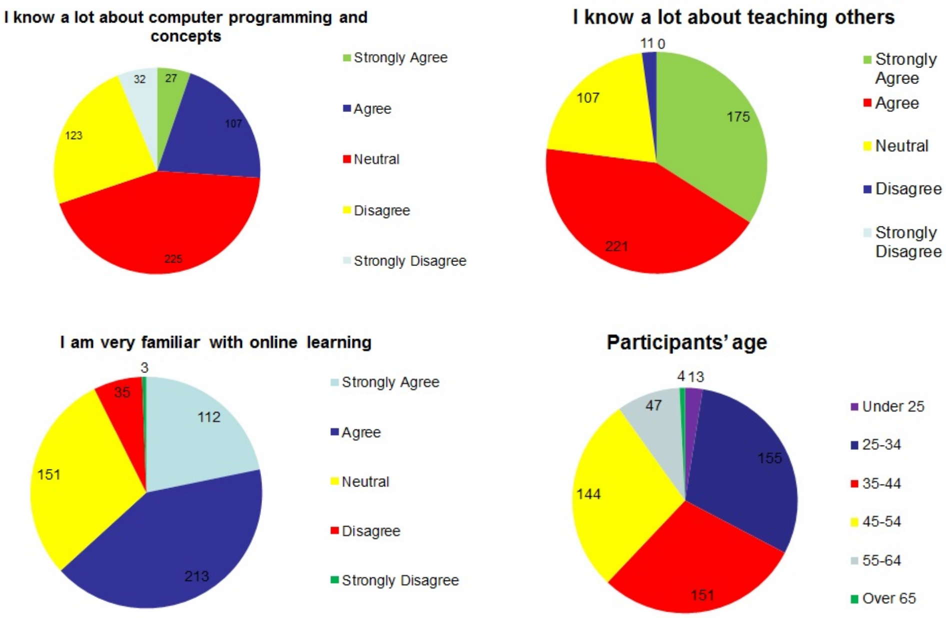

Figure 2 Indicative background information from the pre-course survey

course. After session 2, further requests to join the tutor-supported were turned down but open registrations for the traditional mode were accepted for several weeks more. We were prepared to accept up to 100 registrations on the supported mode, but, as shown in Figure 1, only 30 participants signed up.

The low number of enrolments for the supported mode as compared to the traditional mode was unexpected, particularly as in many cases schools may have been able to sponsor staff from their CPD budgets. We consider this point further below. Although 648 students in total enrolled, 73 of these (11.3%) never logged in to the learning environment.

5.2 Participants' background

At registration, students were asked to complete a short pre-course survey to discover information about their background, their expectations and their thoughts about how they liked to learn and what they wanted to learn. Over 90% of participants were UK-based teachers. Figure 2 shows other participant information taken from the pre-course survey.

	Concepts		**Programming**	
	Slides	Quiz	Slides	Quiz
Session 1	301	687	304	500
Session 2	226	538	216	445
Session 3	126	n/a	105	n/a
Session 4	149	384	143	218
Session 5	130	268	120	186
Session 6	116	196	70	133
Session 7	141	200	115	161
Session 8	122	139	94	127

Figure 3 Access figures for the eight main sessions

Nearly a quarter of the participants thought they had good knowledge of computing already. Over three quarters were confident about teaching. About two thirds were familiar with online learning. The diversity of the answers from the pre-course survey indicates that learners had different reasons for taking the course. The envisaged target group was experienced teachers who needed to make the transition to computing from subjects such as ICT and Business Studies who may well have no programming experience. However, a substantial number were confident in their programming skills and knowledge of computer science concepts. It is likely that this group were more interested in the aspects relating to presentation of the subject at an appropriate level for the new KS4 curriculum. For a number of teachers in the over 40 age groups, a primary motivation was to bring their knowledge up to date. Comments such as "rusty programming" and "skills need updating" indicate that this is an issue for many. It is likely that, with the absence of computing from the school curriculum until now, teachers who had computing skills have not had the opportunity to make use of them. Over 95% of participants were required to teach computing in the coming year to UK GCSE level (students up to age 16). They were therefore likely to have been very focused by the need to prepare for these new teaching duties.

5.3 Resource access

Figure 3 shows the number of accesses logged by Moodle for written resources from the eight main teaching sessions. These logs include individuals making repeated accesses but give an indication of which written resources participants are making greatest use of. This is in addition to the videos which were hosted separately. Students could access each quiz as many times as they wished (perhaps completing part of it and returning later) but they could submit each quiz only once. Figure 3 includes the numbers accessing each quiz, with submissions considered below.

Numbers of quiz attempts in Session 3 are missing as there was a problem in recording these figures. It is interesting that numbers drop steeply for Session 6 but then recover a little for Session 7. This could be because of the topics. Session 6 involved combining knowledge of algorithm development and logical program structure (nesting loops) to implement sorting algorithms. This may have been challenging for some learners.

	Labs				
	Lab A	Lab B	Lab C	% from A to B	% from A to C
Session 1	611	417	367	68.2	60.1
Session 2	448	283	263	63.2	58.7
Session 3	369	259	247	70.2	66.9
Session 4	221	191	192	86.4	86.9
Session 5	198	164	141	82.8	71.2
Session 6	252	137	117	54.4	46.4
Session 7	138	112	99	81.2	71.7
Session 8	132	88	82	66.7	62.1

Figure 4 Number of accesses to lab sheets

In common with the situation for MOOCs in general, there is a steady drop-off in successive weeks. The pattern and proportion of completions is not dissimilar to the 6.5% average MOOC completion rate obtained from data gathered by Jordan [20]. Numbers here for sessions 1 to 4 differ from those reported in [38] as further registrations and progression occurred after the earlier, preliminary figures were complied.

Full transcripts of videos were not initially planned and the effort to produce them began only after the start of the course when a request was received from a learner with hearing difficulties. Once transcripts started to appear it became clear that they were very popular resources and the qualitative feedback indicated that participants greatly appreciated a full written resource. Figures for accessing the transcripts are not included here as they were added later and not all were in place by the end of the first run of the course.

5.4 Lab sessions

The programming exercises (“lab sheets”) were divided into three sections for each session, with each part getting successively more challenging. Dividing the material allowed it to be presented in less daunting chunks with learners able to feel a sense of achievement in completing one part and progressing to the next.

Again, there seems to be an anomaly in Session 6. In the case of the labs, more people than the trend would predict access Lab A. However, a greater proportion than in other session fail to progress to Lab B. Again, this may be to do with trying out the more complex ideas and making a number of attempts with Lab A. Apart from in session 6, the majority of people who access Lab A go on to reach Lab C, with a relatively low fall off observed between Lab B and Lab C in each case.

Overall, many more accesses are observed to the “active” parts of the course (quizzes and labs) than the “passive” learning materials. For some, this may be because they are using these elements to check that their existing knowledge is sufficient without engaging with all elements of the course. Participants appear to be putting the greatest amount of their time into tackling the programming labs and it is interesting to see that the majority of people who access Lab A each session also progress to looking at the (more challenging) part C.

	Concepts		Programming	
	No. submitted	Ave. score/10	No. submitted	Ave. score/10
Session 1	155	7.71	135	7.79
Session 2	132	9.08	114	7.59
Session 4	101	7.85	58	8.95
Session 5	57	7.21	44	4.86
Session 6	50	7.65	30	8.75
Session 7	48	6.63	41	7.82
Session 8	40	8.31	34	8.70

Figure 5 Number of quiz submissions and average scores

5.5 Quiz scores

Figure 4 shows the results obtained in each quiz. Each participant is allowed only one submission for each quiz. Again, figures for Session 3 are missing. As this is the first run of the course, and the first time we have set quizzes at this level, the scores may be assessing our success in question setting as much as the participants' ability to answer. This is likely to be the explanation for the low score on the programming quiz for session 5. However, the figures suggest that participants who submit quiz solutions are generally taking the task seriously and obtaining good results. Although numbers decrease from one session to the next, it is interesting to note that some participants were still working on the earlier material and quiz submissions continued to be received several sessions "in arrears" as judged against our intended course calendar. There was no cut-off date for quiz submission (until the very end of the course) and it was apparent that some participants made progress at their own pace and achieved good quiz scores even though they were, in some cases many weeks behind the currently released session.

Out of the number of initial enrolments 6.2% took the final concepts quiz and 5.2% took the final programming quiz. Considering only the "active" participants (those who logged in to the system at least once), 7.0% and 5.9% submitted the session 8 concepts and programming quizzes respectively.

5.6 Comparison between the two modes

The figures presented so far are for outcomes of the course considering all participants. Figures 6 and 7 provide a breakdown of results between the supported mode and the traditional mode. Figure 6 provides information on persistence, showing what percentage of each group (with respect to initial enrolment) submitted the final quizzes. Figure 7 addresses achievement, comparing the average scores achieved.

It is not unexpected that those on the supported mode showed greater commitment to the course than those on the traditional mode who had not paid to take part. Nearly 70% of the former group took the first quiz as compared to only just over 20% of the latter. Indeed, it is surprising that anyone paying for a course would not make it to the first quiz. It is more difficult to obtain feedback from those who drop out and we do not have data relating to the reasons for these

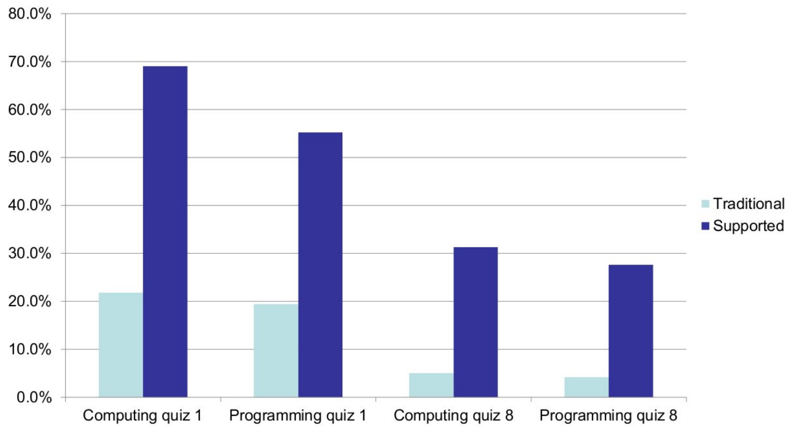

Figure 6 Comparison between modes: percentages submitting quizzes

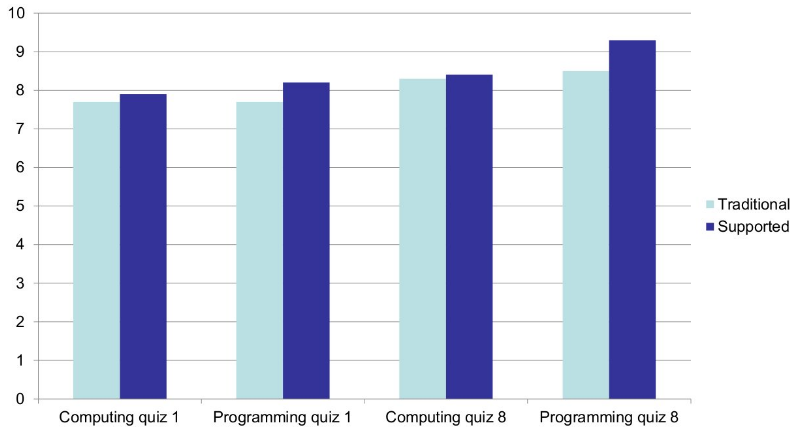

Figure 7 Comparison between modes: scores obtained on quizzes

early dropouts. Roughly 4% of the traditional mode participants submitted the final quiz compared to 28% of the supported mode. Although dropout rates are high for both groups, learners who had made a financial commitment and who were offered frequent tutorial support were seven times more likely to complete.

Figure 7 shows that those learners who persist within both groups continue to achieve average quiz scores of over 7/10. This indicates that, although students on the supported mode are more likely to persist, their achievements are only slightly better than persistent students from the other group. These findings are discussed further below.

6 Qualitative feedback

After each session, participants were asked to fill in a brief evaluation form. Responses were submitted anonymously so in this section we cannot distinguish between the two modes.

Although numbers submitting the form were low, the responses were generally very positive. Over 90% of respondents agreed or strongly agreed to each of the statements that the materials were at the right level, were well produced and provided a good introduction to the topics. Thematic interpretation of the qualitative feedback reveals the following common points. Most frequent positive themes mentioned across both modes of study were:

- gentle introduction (not too intimidating);
- easy to follow;
- good use of simple examples and avoidance of jargon;
- the programming practicals and quizzes;
- good to see the "faces" behind the course;
- non-patronising material, appropriate to target group;
- enough material to challenge.

There are also some very useful observations on areas for improvement and prominent themes here were:

- request for shorter videos (the longest is 24 minutes) and snappier presentations;
- increase quality and volume on audio recordings;
- provide of index to topics covered and where;
- provide "home" button for easier navigation around sessions;
- use most recent version of Python used.

Additional comments from students on the supported mode show that students benefitted from being able to access individual support when needed. There was much praise for the postgraduate tutors, indicating that successful mentoring relationships had been established. However, time constraints and other commitments meant that the real-time hangout sessions were difficult for the majority of learners to access on a regular basis. This was despite the provision of a number of different evening sessions each week. It meant that the establishment of peer relationships was less successful. Although we had not specifically focussed on collaborative, social learning in this project, the hangout sessions were viewed as a good opportunity for learning groups to develop. This did not happen and obviously more thought is needed as to how to scaffold such an approach and to help teachers share knowledge. There were also some issues with the use of the technology for online meetings.

The feedback has been helpful in preparing for the second run of the course. The final point is particularly interesting. The initial plan was to use Python version 3. However, choosing the Skulpt environment meant using Python 2.7. In fact, the situation is even worse in that Skulpt has certain features relating to the print statement which are neither fully 2.7 nor 3. For the second run of the course we have abandoned Skulpt and updated the teaching materials to Python 3.

A mapping of all the topics to be covered and a guide of where to find them plus an easy syntax guide were also commonly requested, showing learners' need to gain a high level view and to quickly reference things they need.

7 Discussion

Here we first consider general issues arising from the development and delivery of the course. A comparison between the two different modes is then presented.

7.1 Environment choices made

Moodle is a popular learning environment which is familiar to many UK teachers. "Doing it yourself" also provides a lot of flexibility and control. However, it does mean that the MOOC development team is responsible not only for developing learning materials but also takes on many other decisions and responsibilities, from video hosting to dealing with user registration. When time is short this can be an onerous task. The use of an external video hosting site proved to be a good decision, relieving the team of one aspect of management. The effort involved in developing a MOOC has been noted by many and, unless dedicated support is available for system development and on-going maintenance, it is very helpful to use an existing system.

For an introductory programming course, an environment such as Skulpt is very useful as it provides an immediate web-based interface for getting started with no installation required. However, there are limitations. The problem of the version of Python supported was mentioned above. This proved to be a concern to teachers as they (and their students) would generally be downloading the most recent version of Python. Also, there are issues with supporting certain aspects such as file handling which mean that moving on to running "real" Python becomes necessary. With hindsight, we have concluded that it is better to face this at the start of the course. The second run will therefore use Python 3 and provide clear video instructions for installing it for a range of operating systems.

7.2 Costs

Producing a MOOC is no small undertaking [41]. Effort is obviously required to develop teaching and learning materials, but time and personnel are also needed to record, edit, transcribe and build the sessions. Administration is needed both for the system and for tasks such as participant registration. Ongoing input is needed to support the hangouts and monitor course queries and forum questions. The team also met weekly for management meetings and MOOC troubleshooting. Obviously, it is hoped that most of the materials will be reusable and subsequent runs of the course will be much less effort-intensive, however, the amount of time needed initially should not be underestimated.

We were grateful for support from a university film crew to help produce a good quality introductory video for each session. However, the time they could offer was limited and all of the teaching videos were produced and edited by members of the MOOC team themselves using standard capture and editing software. Resources needed included: equipment and software for video and audio recording, lecture capture and editing; server; video hosting facility; Moodle platform; programming environment; resource email account.

A rough estimate of costs incurred in developing and running this relatively small MOOC is £22,000. This is a conservative figure based on estimates of time spent and does not include the overheads that would normally be charged to a project.

7.3 Lessons learned

The experience of staff developing such online courses is an important aspect of the MOOC narrative. While there have been some development-focussed reports and estimates of costs (for example by Belanger et al. [2] and Kolowick [24]) there has been only limited discussion of the necessary skills and the amount of input required from a staff perspective.

Although the CfT team members are experienced in teaching computer science, producing and delivering this MOOC has required development of new skills. The different audience, level and mode of delivery have necessitated the development of completely new teaching materials, rather than simply reworking a course delivered to undergraduates. We have experimented with the use of a number of different technologies and platforms and gained experience in lecture capture, audio recording and innovative use of graphics tablets. These are all very useful skills to bring back in to the university context and to incorporate in undergraduate and postgraduate teaching.

There is also a lot to learn about MOOC teaching. Good pace, very short chunks of teaching materials and practical activities are proving important for participants. In addition, we have been surprised by the popularity of transcripts.

Members of the CfT team have not been given remission from other duties so all work on the MOOC has been fitted in around existing commitments. This has proved to be very difficult to sustain at times and on occasion, the delivery of materials for a MOOC session has continued to the last moment. Further, development of a MOOC is very different to the individual face-to-face courses we are used to presenting. It requires project management and forward planning to a degree we perhaps underestimated at the outset.

7.4 Learners' progress

The initial expectation was that the more homogeneous learning community of teachers would make our task easier in that participants would have similar objectives and commonality of background. They might be assumed to be good independent learners and many have a high extrinsic motivation in the need to teach this material very soon. However, teachers are also extremely busy and, even with fortnightly sessions, many have fallen behind. It is interesting to note that many started to engage very late into the course but have since been making good progress. Unlike many courses where it seems that, once behind, participants generally drop out, many of our teachers are coming back to the course and moving at their own pace as and when they can. Thus the usual learning analytics predictors of dropout may not be entirely applicable in this case. It may be that the temporal structure usually associate with a MOOC may not be helpful in all cases.

Because of the shortage of time, for many of our participants the overriding need is to have material to deliver in the classroom. Developing their own wider understanding of the topic is seen as a luxury for which there may not be time. While learning the fundamental concepts of computing and the basics of programming should be achievable for all, it still requires time to become familiar with ideas and practice the practical aspects. Schools expecting teachers to learn these new skills must recognise the need to allow the necessary time. Otherwise there is a real risk of the topic being badly taught by teachers who have not had time to gain confidence in a new area.

Use of forums and peer support has not been particularly effective in the MOOC [34]. This is an aspect which needs to be further developed and better implemented in future development of the course.

7.5 Effectiveness of supported mode

The limited interest in the supported mode (only 30 registrations) was surprising. The cost was very low for the additional services offered, particularly in comparison to much current bought-in CPD. It had been thought that many schools would be keen to sponsor teachers to learn the necessary skills for the teaching they will soon be expected to do. Teachers would have the added benefit of a certificate attesting to their programming skills as evidenced by the assignment. One possible reason for the low up-take is that many of the participants were using the MOOC in different ways, to update or develop certain skills. They may not have wished to engage with the full course or been interested in gaining the additional certification of programming competence. It may also be the case that learners are used to MOOCs being free and that they did not feel the need for or see the value of the additional support that was offered.

The issue of learners' intentions is an interesting one. From the pre-course survey it is apparent that many participants were updating skills or looking for guidance for a new curriculum. It may therefore be the case that they did not intend to follow the full course but were dipping in or just taking the quizzes to confirm their level of understanding. sFor these users, the supported course was unlikely to be attractive as it was aimed more at novices wishing to gain a thorough understanding of the whole course. This, in addition to the different paces of progress through the course, raise questions about the appropriateness of the course structure (indeed, any strict course structure) for many participants.

Hangout sessions were set up with 5 participants to 1 tutor. However, the take-up was been low and in practice 1 or 2 dedicated participants joined their tutor for each hangout. Reasons include difficulty with the timings (teachers often have to attend evening events), lack of progress with the work and a dislike (or disinclination to get started with) the hangout technology.

Persistence of supported users was much greater than for traditional mode learners, but for those participants who did continue in the course, the outcomes were very similar. It is not possible to say how far improved completion rates were due to the commitment of the users, the payment of a fee or the effects of additional support. It is also likely to be the case that the users opting for additional support were those with less background knowledge so it may well be that the increase in learning was greater in order for them to attain similar scores at the end.

7.6 Achievement against goals

Our initial goal was to develop, trial and evaluate a MOOC in which learners could opt for a high level of personalised support if desired. The ultimate goal was to see if this would better support learners within the MOOC. The results noted above show correlation between support mode and persistence, although amongst those who persist, attainment is similar between the groups. It is useful to consider the background and objectives of learners on each mode of the MOOC. Those on the supported mode were generally those who felt the need for additional help, recognising that they had little background or confidence in the topics of study. In contrast, about a quarter of the traditional mode students said they already knew a lot about programming and computing concepts when they started. It was these who, disproportionately, persisted and obtained good results. For this group, the objectives of taking the course were more to refresh and update skills, to gain familiarity with the topics of the new curriculum and to develop classroom pedagogy. Taking this into account, the achievements of the supported group (in attaining similar scores) may be viewed as evidence that the support helped them to narrow their skills gap and reach a similar level to those participants with greater prior knowledge.

The experiment in adding a charge for additional services was not aimed at making money but to explore the possibility of this approach as a scalable way of covering costs for direct tuition. The poor take up, together with the under-utilisation of the hangout session leads us to conclude that out efforts would be better directed at supporting all learners and we have chosen to offer the course in a single (traditional) mode only for its next run. We also note the different motivations that learners have for taking the course. Although many require a guided, linked course, for the substantial minority with prior experience, the ability to access individual topics as required would be very useful. MOOCs are currently generally very inflexible in this respect and do little to scaffold access to individual learning topics (for example, clarifying prerequisites and helping users test whether they meet them; providing visualisation of which topics the learner has already studied). We therefore plan to investigate how the MOOC format could be developed in this way.

8 Conclusions

Overall, the CfT MOOC has been successful, and the second run is now underway. The format and content have been updated to consolidate materials into a single mode of delivery and to change to the most recent version of Python.

On the supported version, completion rates were seven times higher than on the traditional mode, but attainment levels for completing uses were very similar for both groups. Uptake of the supported mode was low and fixed time hangout sessions were not well used. In the future, any additional resources may be better-placed in supporting all participants with active monitoring and responses to the programming forum and additional "community building" activities such as weekly topical discussion threads to encourage active engagement. Instead of times fixed in the diary, we are considering introducing dynamic, ad hoc group collaboration allowing learners to work together with those at a similar stage.

The British Computer Society is currently piloting a scheme to offer accreditation for teachers moving into computing and a we hope that in future it will be possible to gain automatic accreditation for successful participants in our course.

We are also considering further ways to best support teachers, for example with a "mini MOOC" with reduced content to be offered in a short time period, for example during a week in the summer holidays, or with a MOOC directed at school students. As noted above, as a result of our findings we are also planning a more flexible presentation of the resources which will provide a more structured interface into the resources in order to facilitate user-driven learning paths.

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