Moving MSc Software Development course online: adaptation of the large class module to a distance learning model

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***Abstract*—The Covid-19 pandemic brought dramatic changes to higher education settings, particularly for curriculum delivery, moving quickly to online learning in March 2020, which for many was the first experience of teaching and learning in the virtual environment.**

This paper discusses the experience of redesigning the MSc Computing Foundations module and adapting it to a distance learning model using both synchronous and asynchronous delivery at the School of Electronics, Electrical Engineering and Computer Science, Queen's University Belfast in response to the challenges brought to higher education by the pandemic. The module is a fundamental compulsory module with an intake of 100+ students in the part-time class studying the conversional MSc course in Software Development.

This paper focuses on the challenges and opportunities faced by large class students during this unprecedented move online, and changes made to the curriculum to facilitate the move to online teaching and learning using the conceptual framework for effective online courses. The paper reflects on student feedback to online educational activities including synchronous and asynchronous content delivery, discussion forums, ungraded formative quizzes, formative and summative assessments delivered online for a postgraduate cohort studying part-time. Sustained level of student engagement was evidenced through statistics collected from the virtual learning environment.

This paper further discusses how the above has transformed teaching of the Computing Foundations module for the large cohort, focusing on the student experience only, and reflecting on how these online teaching practices contribute to provision of education with a view what developments became a success and could be turn to advantage and what was not effective and should be eliminated post-pandemic. Adaptation of the Computing Foundation module to the new model of online delivery has been successful in the 2020-2021 academic year, and the module has become a distance module delivered fully online in the 2021-2022 academic year. The transformation has helped to cope with a "new normal" in an increasingly hybrid higher education ecosystem as students' and educators' involvement into learning activities continued to be altered in the post-pandemic society.

Keywords—online learning, Covid-19, large class, technologies in education

I. INTRODUCTION

According to UNESCO data, published in 2020, learning for more than 1.5 billion students worldwide have been affected by the Covid-19 pandemic [1]. That impact has become abrupt and brought dramatic changes into higher educational settings with much face-to-face teaching moving to the online format. Online teaching and learning that was performed since March, 2020 cannot be considered the same as planned or prepared online learning due to its different nature. "Pandemic" online teaching and learning was forced to break in, while the "planned" online learning is primarily defined by preparation and orientation to the online environment [2]. Teaching and learning under the crisis conditions became a challenge to many students and academics, as they had to learn how to survive this "new normal" and orient themselves in online "terra incognita" [3]. For many courses, the online learning environment was traditionally considered as supplementary source to the face-to-face teaching, e.g., seen as a repository for materials, which has now transformed to the main source for teaching and learning with the different pedagogical understanding of the educator's role [4, 5]. New principles had to emerge for moving large classes to the online environment during this time of unexpected changes, as solutions had to be provided quickly and under pressure [6].

This paper discusses how the pandemic crisis conditions have transformed teaching for the large cohort, studying part-time Software Development course at the School of Electronics, Electrical Engineering and Computer Science (EEECS) in the Queen's University Belfast (QUB), focusing on the student experience only. Moving to a new model of delivery would normally take place after a period of consideration of module structure and learning outcomes, providing a rationale and justification for changes which can be accepted by faculty, and curriculum review. In unprecedented times of the Covid-19 pandemic, it was required to make this very significant shift under crisis conditions that demanded from educators to challenge their assumptions and perceptions, as well as provided them with an opportunity to restructure their teaching and principles of learning for large cohorts [7]. Under new conditions, it was necessary to redesign a face-to-face synchronous, 20 CAT Computing Foundations module on the MSc Software Development course, with the module comprising 100+ students, into engaging online format. This paper explores the experiences of redesigning the Computing Foundations module with a particular focus on how the conceptual framing for effective online courses [8] informed the transformation of the module for synchronous delivery and asynchronous online learning environment. The conceptual framework is illustrated on Fig. 1 and includes the full cycle of an online course with a focus on online course design, assessment and evaluation, and facilitation [8].

Methodology types employed in this case study include online observation with statistics collected from the virtual learning environment (VLE) Canvas, quantitative analysis, individual student surveys of teachers work – Module Evaluation Questionnaire (MEQ) and Teaching Evaluation

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Questionnaire (TEQ) for the Computing Foundations module – comprising open and closed questions and collected by the EEECS.

Fig. 1. Conceptual framework for effective online courses: design, assessment and evaluation, and facilitation [8]

Data were drawn from separate MEQ and TEQ for the Computing Foundations module. The software EvaSys Evaluation was used to represent and interpret the data as a tool for efficiency, but was not used as a tool of conducting analysis or drawing conclusions.

II. Computing Foundations Module: Teaching Context

At the beginning of the 2020-2021 academic year academic programmes taught at the School of Electronics, Electrical Engineering and Computer Science in Queen's University Belfast had to be transformed and delivered online that forced all module owners to redesign curriculum in order to meet distant module delivery expectations. The technologies involved were Microsoft (MS) Teams and the Virtual Learning Environment (VLE), Canvas [9]. MSc Software Development course is one of the largest MSc cohorts in the EEECS with an annual intake of 100+ students for each full-time and part-time class. The Computing Foundations module introduces fundamental elements of computer science for students that are studying a conversional part-time MSc course in Software Development, Year 1. The part-time option is taught in the evenings (two evenings a week per semester) and spread over 3 years to allow students to study while in full-time employment. Prior to the Covid-19 crisis, the part-time Computing Foundations module was arranged in a traditional face-to-face delivery mode with lectures in a large lecture theatre, and tutorials in the lab. The module was introduced and became a part of the curriculum in 2019-2020 academic year and had been taught in person for one year before the pandemic started. Students were required to take two in-term computer-based assessments. The size of the cohort and the practical character of tutorials presented a challenge for moving the module online, augmented by the fact that the audience's previous backgrounds are various, i.e. for some students they are not related to the computing subject at all, and with significant prior experience and knowledge of module elements for others.

The online delivery of the module was considered from the prospective of the conceptual framework for effective online courses and subsequently divided into 3 main sections:

- Course design that is underpinned by synchronous and asynchronous content delivery;
- Facilitation and engagement with students via MS Teams and VLE Canvas;
- Formative and summative assessments delivered online.

III. Content Delivery: Synchronous and Asynchronous

Various asynchronous and synchronous models of delivery have been reported in the literature to highlight their positive and negative sides [10, 11]. Many authors suggest the importance of setting up and supporting students through a "classroom" environment in order to promote online interaction and their engagement that involves both synchronous and asynchronous learning opportunities [12, 13].

The importance of course structure [8] and the need for a systematic approach to content design for the Computing Foundations module has resulted into a decision to organise the course into weekly topics and assignments, splitting content and providing clear recommendations relevant to course that helps facilitate student learning. Consistency in structure from week to week allows students to know where they are within the learning process. One of the important aspects was presenting the nature of the interaction required in the online course to students. Clarification of expected participation, standards of contributions and interactions and deadlines were explicitly explained to them.

The main consideration for the Computing Foundations module was how to maintain a balance between both synchronous and asynchronous modes of delivery, followed by how to facilitate tutorials. Synchronous mode of delivery seemed to be more familiar to academics and considered to be a more engaging mode of delivery for students as they could interact with their peers and lecturers during "live" sessions [14]. However, to meet the requirement of joining virtual classroom at particular time, students needed internet and computer access with specified bandwidth [15]. This became impossible for students belonging to low-income groups [16], but also created difficulties for those with multiple members in the household trying to access devices and internet connections simultaneously.

Asynchronous mode of delivery is considered to be rather suitable for MSc students as they had flexibility in terms of accessing study material at a time and place available for them, because the majority of the MSc part-time class had parental and caring responsibilities and also preferred to access technology while in a university, e.g., at the Library space, rather than being at home. Some studies have suggested that asynchronous mode of delivery contributes to processing and better understanding of information, and may increase the quality of learning [17]. On the other hand, this mode of delivery has limitations in terms of supporting interaction and creating learning communities [14].

The specific student audience had also to be taken in consideration with reference to part-time students who often work full-time and have caring responsibilities. Mainly due to the class specifics and technology considerations, it was decided to include both asynchronous and synchronous modes of delivery. The former involved recording of 15-minute videos covering weekly structured material and uploading the videos on VLE Canvas that followed by quizzes to provide a feedback, and the latter was delivered through holding live

lectures, tutorials and feedback sessions via MS Teams. Another strategy embedded into the module structure was the live delivery of lectures via MS Teams with concurrent recording of the same lecture and uploading it in Canvas afterwards using MS Stream. This appeared to be a good strategy as student feedback was extremely positive and the majority of the class (78%) mentioned watching of those pre-recorded videos as an effective revision tool while preparing for assessments.

Having asynchronous material available was important, because it gave flexibility to the MSc students to revise the lecture notes and practical challenges as many times as they needed, and learn the missed computing subject concepts when they could not attend a live lecture due to work, caring responsibilities or sickness. Students responded:

"The resources were clear and well organised. The lectures were also easy to follow and what was being covered each week was clearly laid out. I also liked the fact that there were pre-recorded short videos and recorded live lectures that helped to catch up with the material at my own pace

"Everything that was expected was presented clearly, and easy to understand, videos were really helpful to revise some topics. I am happy that I can watch the videos at my own leisure and online, this is essential to me to completing this course as I would not be able to attend live lectures."

IV. Facilitation and Engagement with Students via MS Teams and VLE Canvas

Online course facilitation refers to how the module owner arranges interactions with students to help them meet learning outcomes [8]. There is much discussion in literature about the teacher's personally that influences the large-class teaching concept proving that better engagement leads to better achieved learning outcomes [18]. Notably, "creating a classroom community in large classes is key to active discussion and interaction" [19, p. 6]. Deep learning in such a class is become possible when there is relationship between learners and instructor leading to increased learners' motivation [20, 21]. Such "human" and engaging approach has become an integral of successful teaching large classes during the pandemic [6].

While having a class size of 100+ , the decision had to be made on how to build such relationship during live classes. To facilitate student engagement during live sessions in MS TEams, we used the Chat function for learners to ask questions. Another technique that was employed to engage with them was a poll asking students to indicate their mood using cartoon and funny animal scales, as well as responding on my brief funny remarks etc. This usually worked well at the beginning of the class as an "ice-breaking" technique helping them to relax that normally got a lot of responses. That was very well received by students: *"Always made to feel like a part of the lecture, very inclusive and class participation encouraged. Especially relevant and enjoyable with the remote learning aspect."*

Another point to consider during online lectures was the difficulty in measuring student engagement and understanding of the material during live synchronous sessions. To measure the level of engagement I included a few MS Teams Forms quizzes at regular intervals of 15 minutes after the short block of information. This gave the students an opportunity to switch their attention and avoid monotonous delivery, and also receive some formative feedback on their newly formed knowledge in a relaxed informal way. I also provided these Forms quizzes as learning tools for the students at the end of each section to get them engaged with the material.

To avoid monotonous and "monologue-type" delivery during live sessions, YouTube videos illustrating some computer subjects concepts (such as sorting / searching algorithms, number systems, etc.) were offered to learners to enhance their learning. In addition to polls in MS Teams and engaging learning activities, Discussion forums on Canvas were included after the relevant topic was covered during live lecture classes. That helped to provide engagement and a learning tool for the entire class, as questions received from students via email or Teams were uploaded with explanations and answers onto Canvas board.

The comments and requests from the class, provided by student representatives on Student Voice Committee meetings, was also taken into consideration. Student feedback and suggestions helped to adjust ways of teaching during the 2020-2021 academic year and get a sense of class satisfaction.

V. Assessment and Evaluation: Formative and Summative Assessments

Assessments in large-classes are traditionally considered to be a challenge, especially when online tools and technologies are involved [22-25] that implicates necessity to give meaningful feedback to large numbers of students [25, 26]. Some authors have developed much expectations and provided evidence of student response systems effectiveness [27, 28].

Managing the class of 100+ students and provision of qualitive and timely feedback on their knowledge and skills became a challenge. To address that, possible online formative assessment options and applications were searched for, and, subsequently, a series of weekly formative online assessments in the form of Canvas quizzes were designed [9]. Quizzes, including mock exam, were designed to eliminate the gap between learning theoretical concepts and their practical application, i.e. the students lacked training practical skills, which are vital for learners in computing subjects. Designed for self-assessment purposes, the weekly quizzes have allowed repetitive practicing and provided immediate feedback on students' knowledge and skills.

Sustained level of student engagement was observed: statistics collected from VLE Canvas show that quizzes were widely used, and that the quizzes with the highest number of attempts strongly correlate with the highest student marks scored on the summative assessment.

Fig. 2 represents the formative assessments statistics for the part-time cohort: x-axis indicates the quiz scores (percentage) reflecting student performance and y-axis represents the number of students who took mock exam (117 respondents, in total). The quiz summary also shows the quiz average score, high score, low score, standard deviation (how far the values are spread across the entire score range), and average time of quiz completion.

Providing automatic feedback and frequent opportunities of using online quizzes helps students learn through diagnosing their own mistakes. Quizzes were very well received by students:

"I appreciated regular exercises and formative quizzes implemented to reinforce learnings week on week. I also really enjoyed the feedback and revision sessions held by the lecturer. They showed areas of common mistakes and topics where students traditionally scored lower."

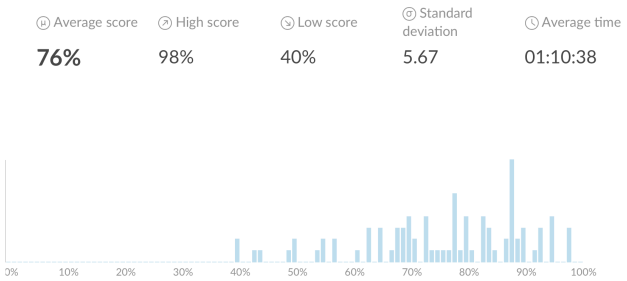

Fig. 2. VLE Canvas statistics for the Computing Foundations module: formative assessment (mock exam)

There were no modifications made to the summative assessment model compared to the face-to-face delivery: the students took 2 in-term assessments delivered on VLE Canvas in the form of online tests containing multiple-choice, short open-response and larger open-response questions.

VI. Reflection: What did become a success?

Adaptation of the Computing Foundation module to the new model of online delivery has been considered to be rather successful in the 2020-2021 academic year. We observed high level of student engagement with the content on Canvas, they worked independently through videos, pre-reading resources, pre-recorded videos and completing quizzes in advance of attending live sessions. The live online sessions in MS Teams have had consistently high attendance with between 75% and 85% of the class logging in every session up to week 12. This is even higher than attendance at in-person lectures and tutorials for the module in the previous year. Even the optional revision sessions held in week 6 and week 11 had 87% attendance of part-time MSc students.

As per Module Evaluation Questionnaire, comprising responses from 45 students, 82% of them attended 76-100% of live online teaching sessions, 13% attended 51-75% of live online teaching sessions and 4% attended 26-50% of live online teaching sessions (Fig.3).

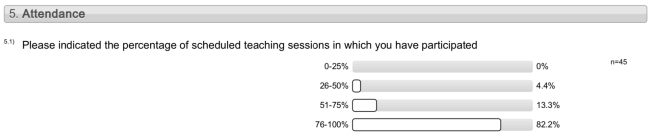

Fig. 3. Module Evaluation Questionnaire for the Computing Foundations module: class attendance

Overall student satisfaction with the module was 4.7 out of 5 according to the Module Evaluation Questionnaire, and student satisfaction with the online teaching was 4.9 out of 5 according to the Teaching Evaluation Questionnaire (Fig.4 and Fig.5):

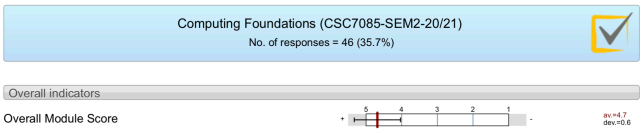

Fig. 4. Module Evaluation Questionnaire for the Computing Foundations module: overall module score

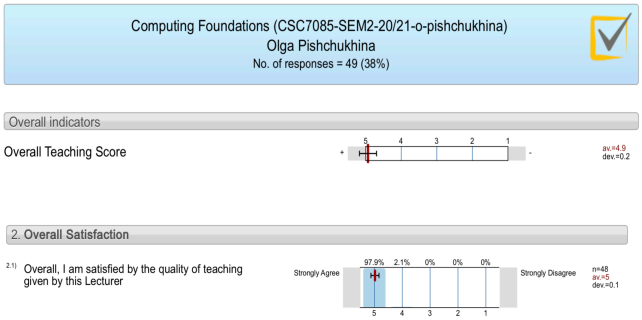

Fig. 5. Teaching Evaluation Questionnaire for the Computing Foundations module: overall module score

As per formal student feedback, the majority of the class appreciated asynchronous mode of delivery that included lecture pre-recorded videos, practice challenge, formative quizzes, revision material and other content on VLE Canvas. They reacted very positively that they were given the opportunity to access content at a time and a pace that suits them with multiple attempts. Some of them commented:

"I suggest to keep this format available and deliver part time modules online to the same extent post Covid. My job requires working away so it will be unlikely that I will make any classes next year in person. It would therefore be very beneficial for classes to be delivered online to the same extent even after Covid restrictions relax to enable me to continue with this course."

"The lectures were well organised and easy to follow and what was being covered each week was clearly laid out. I also liked that each assessment had clear learning outcomes that were being assessed. There was no confusion over what would be examined."

According to the Module Evaluation Questionnaire, comprising responses from 46 students, 85% of the students were satisfied with the module content and found it well-prepared and well organized (Fig.6):

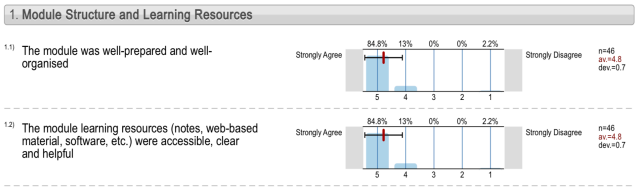

Fig. 6. Module Evaluation Questionnaire for the Computing Foundations module: module structure and learning resources

The majority of students found the criteria used in marking clear (83%), assessment arrangements and marking have been fair (91%) and feedback received in line with School policy (94%) that is represented on Fig.7 and Fig.8:

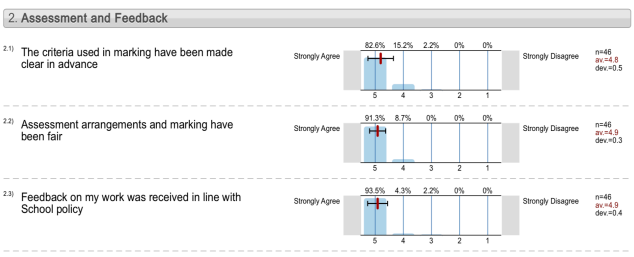

Fig. 7. Module Evaluation Questionnaire for the Computing Foundations module: assessment and feedback

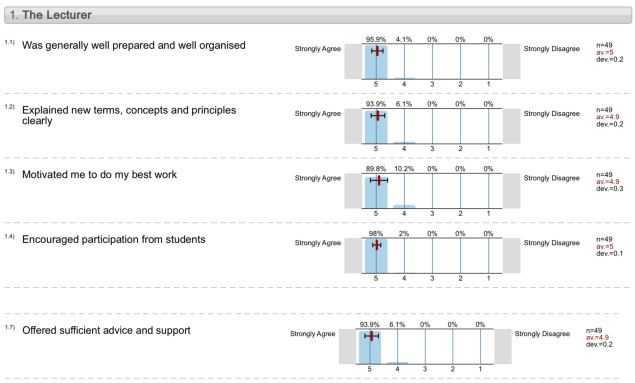

Fig. 8. Teaching Evaluation Questionnaire for the Computing Foundations module: facilitation and engagement with students

Student feedback on facilitation and engagement with the class was also overwhelmingly positive with 98% of respondents satisfied with their participation and offered advice and support. The average student performance for the Computing Foundations module taught online in 2020-2021 was 68.7 %, that is consistent with the average of 68.4% for the Computing Foundations module taught in-person in 2019-2020 academic year.

VII. Reflection : What did not work well?

Social activity elements were obviously missing by lecturers and the student cohort. Thinking of what did not work well, it's worth mentioning lack of social interaction and opportunities to build learning communities between students in the class as well. Students commented in TEQ/MEQ surveys, that the part of learning they missed was mostly relevant to absence of "human communication" with classmates and sharing their learning experiences. This must have been particularly challenging for Year 1 part-time MSc students studying the Software Development course, as they had not had an opportunity to collaborate with peers before and had no prior experience at QUB in general and EEECS in particular, and would not have already been familiar with EEECS virtual labs and software or virtual learning environment Canvas.

There is much discussion in the literature on the issue of presence and connection while teaching and learning in large class, with both staff and students experiencing a sense of isolation [6]. The data from our surveys indicates that reduced synchronous teaching and limited peer-to-peer and student-teacher interactions may become a problem, as virtual class room despite its proved viability is not that enjoyable as "normal" class room that is shared with peers.

VIII. Conclusion

The redesign of the Computing Foundations module in order to be delivered fully online became a challenge as it had to be done under unprecedented circumstances during the global pandemic. The redesign of the Computing Foundations module was generally successful in terms of meeting the needs of large cohorts. Student feedback indicates that they were satisfied with the module but that they would benefit more from a blended or hybrid approach, which is consistent with the findings evident in the literature [6]. The redesigned Computing Foundations module, that proved to be a successful module in the 2020-2021 academic year according to the MEQ/TEQ = 4.7/4.9 (out of 5, respectively), has been retained as an online module for the part-time cohort and being taught in the same format in the 2021-2022 academic year. While teaching online is certainly different [4], many practices are transferable to the face-to-face environment, and aspects of the redesigned module will be kept for the 2022-2023 academic year if there is a return to face-to-face teaching for the part-time MSc class studying the Software Development course. The opportunities for novel learning moments offered by the use of both synchronous and asynchronous models can be used to enhance teaching method for large classes environment [6]. It's worth mentioning that maintaining a balance between synchronous and asynchronous engagement supports teacher presence and improves perception of the course in general. Synchronous learning activities, in particular, provide opportunities for students to communicate with their large class teacher in real-time, e.g. to ask questions and debate module content during live lectures. However, asynchronous learning activities increase accessibility of remote, emergency teaching, that was evidenced in our survey by students. Utilizing the conceptual framing for effective online courses [8] as a frame of reference for pedagogical redesign was important as neither lecturers nor students were unfamiliar with the experience of asynchronous teaching and learning. While the above study is concerned with the implementation of online learning to large cohort teaching, many of the findings could be applied to any class size.

Adaptation of the Computing Foundation module to the new model of online delivery is considered to be successful in the 2020-2021 academic year according to returned student feedback, and the module became a distance module delivered fully online in the 2021-2022 academic year. The transformation has helped to cope with a "new normal" in an increasingly hybrid higher education ecosystem as students' and educators' involvement into learning activities continued to be altered in the post-pandemic society.

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