Overcoming the Sudden Conversion to Online Education During the COVID-19 Pandemic: A Case Study in Computing Education

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***Abstract*— This paper presented a case study on an agile shift from brick-and-mortar to online distance learning as a measure to sustain teaching and learning in higher education in response to the interruption and impact brought by the outbreak of Novel Coronavirus Pneumonia (COVID-19) to the society. This case study provided a practical example demonstrating possible practices that can be adopted to deliver different types of modules and carry out assessment under force majeure circumstances. We have applied several methods in module delivery and reflected on their strengths and weaknesses. Our approaches have taken into consideration the different needs of taught and non-taught modules, robustness of online assessment, and quick orientation for students who were unfamiliar with online education. The consequent effectiveness of teaching and learning was evaluated in terms of instructor participation and student participation. The findings indicated a relatively slow start due to the series of necessary adjustments to be made to encounter the shift. However, once the adaptation process was completed, an enhancing trend was observed in students and instructors' engagement in various online teaching and learning practices. Our study highlighted that pastoral support is essential to maintain the motivation and engagement of students. In addition, adjustments to module delivery and assessment methods are highly recommended.**

Keywords—COVID-19, computing programme, class suspension, classroom teaching, online learning

I. INTRODUCTION

The first case of Novel Coronavirus Pneumonia (COVID-19) in Macao, a southern city of China, were reported on 21 January 2020. A series of preventive and control measures were rolled out in the city. Temperature screening, health declarations and restricted entry were in place at ports of entry and public venues. The use of surgical face masks was requested at all time during out-of-home activities. Non-emergent public facilities (e.g. government buildings, schools, universities, parks, public libraries, sport facilities.), services and activities were suspended, people being advised to stay home and avoid crowd gatherings [1].

In response to the COVID-19 pandemic, higher education institutions in Macao suspended all classes starting from late January 2020 until further notice [2]. In view of the uncertainty generated by the pandemic on education provision, an agile shift from brick-and-mortar to online distance learning environments became imperative in order to sustain teaching and learning, reducing the impact of the pandemic on students' future development. Such a shift tended to be challenging given the limited time for the series of necessary adjustment to the common teaching and learning behaviours and practices.

At higher education institutions in Macao, face-to-face teaching and learning is the major and accustomed method for module delivery. A fundamental paradigm shift for both instructors and students was required in order to implement online distance learning. Existing learning activities, which were designed for brick-and-mortar or blended learning purposes, were expectantly incompatible to online distance learning environments. It was necessary to review and modify them as well as to reallocate teaching and learning resources for online module delivery along the way.

Class suspension started amidst the Chinese New Year break. The semester had run for three weeks at most higher education institutions before the suspension. Students were off from campus empty-handed for the holidays and festivities thinking that the semester would resume shortly. Students' lack of textbooks and learning materials they had been using was to be considered during redesign of teaching plans. Capstone practical modules, such as internship and teaching practices, rely on supervised work experience gained from external entities. They do not fall within the conventional sphere for online teaching and learning. Alternative measures were to be devised to help students achieve the expected learning outcomes.

Student engagement and retention are commonly noted problems in online distance learning [3]. Studies found that the outcomes of online distance learning depended largely on students' self-regulation, module design, instructor engagement, and student support mechanisms [4][5][6]. Under the pandemic circumstances, given the geographical distance between instructors and students, it becomes paramount to devote extra efforts to monitor students' learning motivation and behaviours in order to inform adequate design of learning activities and timely learning intervention, sustaining students' learning experience.

This paper presents a case study on the online delivery of teaching and learning during the COVID-19 crisis in the undergraduate Computing Programme offered by the Macao Polytechnic Institute (MPI), a public higher education

institution in Macao. The remainder of this paper is structured as below. Section 2 presents the institutional infrastructure and mechanisms for online learning. Section 3 discusses the approaches adopted by the programme for modules which had been taught face-to-face in brick-and-mortar settings. It describes our experience in implementing several methods to deliver modules online and reflects on their strengths and weaknesses. Section 4 introduces the alternative measures adopted to deliver capstone practical modules and extracurricular activities. Section 5 demonstrates the assessment methods adopted during class suspension. Section 6 presents the evaluation of teaching and learning effectiveness under this special circumstance. Section 7 summarises our study and presents recommendations, followed by an overall conclusion of our study in Section 8.

II. Institutional Infrastructure For Online Learning

At the Macao Polytechnic Institute, teaching and learning are delivered in a brick-and-mortar setting facilitated by a learning management system (LMS), which is basically a blended learning approach [7][8][9]. During class suspension, the LMS became the major environment in which teaching and learning took place. With the aim to ensure students' learning experience during the pandemic, an online conferencing system and an online video system were integrated onto LMS. In this way, instructors were provided with a one-stop platform for preparation and dissemination of learning materials, learning activities (such as online lectures, quizzes, forum discussion, etc.), as well as monitoring of students' learning behaviours and engagement.

To reinforce effective use of the systems and tools, relevant theme-based tutorial videos were reviewed, revised and updated for use by students and instructors. Online individual and emergent IT support was in place to cater to the various issues and problems they encountered when working from a distance. With an awareness of the importance of instructor engagement in online learning effectiveness [4][5][6], a series of online teaching and learning workshops were offered to all instructors. In addition to the usage of the various systems and tools, particular emphasis was given to the analytics reports extractable from the systems and the interpretation of relevant statistical indicators. Those reports were aids to inform instructors of student participation for timely learning intervention.

Apart from the online systems and tools, two instruments were developed for use respectively by module instructors and programme coordinators (similar to the role of a department head in an academic faculty) for self-reflection about the teaching and learning process. This is to ensure instructors' self-awareness and regular review of student participation, learning progress and effectiveness. For module instructors, the instrument requested a record of the learning materials uploaded and the learning activities conducted as well as a review of student participation, teaching and learning effectiveness, and difficulties encountered and relevant solutions. The data collected were reviewed by the programme coordinators, who are responsible for coordinating all teaching and learning affairs within the programme. Using the second instrument, the programme coordinators reviewed and analysed the teaching and learning effectiveness of their programmes. Their analyses were then reviewed by their school directors (similar to the role of a faculty dean) who are to ensure effective teaching and learning across programmes within the school.

As always, student feedback is an important indicator of teaching and learning effectiveness. To reinforce the communication with students on the institutional level despite the distance, an online portal was created to collect students' feedback about their online learning experience. Students can make use of this portal to express their opinions on the online learning opportunities they had received, seeking institutional attention on their learning needs and difficulties. The student feedback collected was centrally disseminated to respective schools for their response and follow-up actions where necessary. The schools were required to respond to the feedback in a week's time upon receipt of the opinions. The entire feedback-to-action process was equally reviewed on a regular basis on the institutional level for consistent practices across the Institute.

All the review exercises stated above were conducted on a weekly basis to be in line with the rapid online pace. Similarly, a directorial meeting (i.e. faculty deans' meeting) was held every week starting from the first week of online module delivery. These meetings, chaired by the President of the Institute and participated by heads of academic support services (e.g. the registry, the student affairs office, the pedagogic affairs office, the IT department, etc.), were to sustain institute-wide communication, share good practices and resolve common problems or issues encountered. The overarching objective of the entire mechanism was to ensure timely response to students' learning difficulties and sustain their learning experience despite the difficult and unusual situation.

III. Substitutes for Brick-and-Mortar Learning Settings

The Computing Programme at the MPI consisted of lecture-based, laboratory-based, and practice-based modules. During class suspension, several approaches have been taken to maintain teaching and learning in lecture-based and laboratory-based modules where brick-and-mortar learning settings are usually required.

A. Online Lecture

To maintain similar learning experience, instructors tended to convert in-person lectures to online lectures using the video conferencing system. The online lectures were synchronised with the original lecture schedules. This approach has several benefits. First, both students and instructors are familiar with the teaching method (i.e. lecture) and thus less resistant to the shift. By maintaining the original lecture schedules, instructors can maintain students' learning pace and mitigate their inertia in distance learning. Moreover, online lectures allow classroom-like interaction among instructors and students, which enables students to obtain immediate responses.

However, some features of in-person lectures cannot be easily transferred to online settings, which requires instructors' extra efforts to maintain teaching effectiveness. First, some students may not be able to attend online lectures at the scheduled time due to various difficulties encountered during the pandemic. This can be mitigated by video-recording the lectures so that students can review the lecture videos at their convenience. Another limitation is the lack of non-verbal communication. In an in-person lecture, an instructor can drive students' attention using gestures or teaching props (e.g. whiteboards). In an online lecture, the instructor needs to use on-screen symbols or formatting for

this purpose. Finally, teachers are unable to observe students' immediate reaction. This is particularly so as students tended to join the online lectures without switching on the camera and microphone. Instructors can obtain little hints of student engagement, which makes offline revision exercises necessary in order to understand students' learning situation.

B. Multimedia Materials

Recorded online lectures allow students to review the lectures after class. Some students may find it difficult to maintain constant focus and engagement when watching the videos passively. In response to this, multimedia materials (audio slides / video lecture) were prepared by topics, which are more engaging than long lecture recordings because of the clear foci. Students can digest each topic at their own pace rather than consuming many topics in one go. These materials are also organised into a playlist for each chapter so that students can conveniently navigate among the topics and re-watch the videos for challenging ones. However, for both recorded online lectures and video lectures, students are required to be self-disciplined and motivated as they are to schedule their own study.

C. Computer-Based Laboratory

Laboratories are essential for Computing students to gain hands-on skills and deepen their conceptual understanding as in, for example, programming, database design, network configuration, and operation of specialised software tools. In line with the module syllabi, most laboratory sessions during class suspension are software-based. Students can generally replicate similar laboratory environments at home. As such, instructors tended to record videos to explain system setups and laboratory procedures. Aided by the videos and the lecture notes, students were thus guided to install the required software on their own machines. Alternatively, instructors can deploy temporary servers with data for teaching. This allows students to carry out laboratory work in the cloud at their own place and pace.

D. Interaction and Discussion

A number of online tools were utilised to complement interpersonal interaction in online module delivery. In addition to online lectures which enable real-time interaction between students and instructors, the forum on the LMS was made use of to trigger questions and answers, facilitating discussion and peer learning. For students who need particular learning support, individual online meetings were arranged to provide individual learning advices and guidance. Common social media applications were used to maintain effective group communication within the class. Together with the year tutor and student representative systems, which have been in place as part of the quality assurance system of the Institute, these online means secured effective communication and interaction among students and instructors.

IV. Alternative Measures for Capstone and Extracurricular Learning

At the Computing Programme of MPI, capstone experiences consist of teaching practice for students specialised in IT education, internship for students specialised in enterprise and gaming systems, and/or research projects applicable to all students. Those experiences are supplemented and supported by various extracurricular learning opportunities for students' holistic development in their respective field. Due to the culminating and integrative nature of these learning activities, alternative measures were adopted to help students acquire relevant expected learning outcomes via the use of online means..

A. Teaching Practice

Students specialised in IT education are trained to serve as secondary school teachers in Computing. In order to be a registered Computing teacher in Macao, they are required to practice classroom teaching in secondary schools for 90 hours within 28 weeks under the supervision of a mentor from respective schools. During the pandemic, the students were practicing for an average of 35 hours within 11 weeks (the teaching hours varied across different secondary schools depending on the progress before class suspension). As part of the anti-epidemic measures in the city, class suspension started from late January 2020 in all schools until further notice [10] . All brick-and-mortar teaching practice was correspondingly suspended.

In response to the situation, students' teaching practice was translated to online environments in line with the online learning policy adopted at the schools. With the joint efforts of the schools and the programme, the students were assigned to develop and deliver an online learning module under their mentors' supervision. The development involves the drafting of the module outline, the choice of teaching materials, the design of lesson plans, to the production of teaching videos, exercises, assessment activities and marking schemes. The entire process is equivalent to the normal routine of teaching practice except that it took place in an online environment. With the first 17 weeks of teaching practice completed in a brick-and-mortar setting, these 11 weeks provided students with extra online teaching experience in addition to reinforcing the normal teaching routines.

B. Internship

Internship is a 1-semester elective module for students specialised in enterprise and gaming systems. Students are required to complete 45 hours of internship at enterprises under the supervision of a mentor from the workplace as well as reflect about the experience gained in the form of a report and a verbal presentation. This is to enable students to gain work experience in their field of interest for preparation of their career development after graduation. During the pandemic, for safety sake, the work-from-home policy was extended to internship with the joint efforts of enterprises and the programme. Students were assigned with computing-related tasks, on which they can work at home. Online supervision sessions were provided to them on a weekly basis, during which the in-house systems of the enterprise and some latest technologies were introduced. This approach sustains the goal of broadening students' vision, facilitating their internship reflection.

C. Projects

The fundamental capstone experience of the Computing programme is the Final Year Project, a one-year research-based module which all students are required to undertake during their final year of study despite their specialisations. In this module, a student needs to define a problem, design and implement the solution, manage the technical uncertainties and potential risks, and write a technical report under the supervision of an instructor. When class suspension started, students reached the stage of finalising their implementation, analysing their work, producing the results and drafting their reports. Given their seniority, these students are generally

motivated and technologically competent in online discussion with supervisors, document revision control, and system demonstration. As such, they continued their project at home and maintained constant communication with their supervisors using various online means. Upon completion of the reports, students would present their work to the assessment panel via video-conferencing to complete the final stage of the module.

D. Extracurricular Learning Opportunities

Extracurricular learning opportunities are an important mean in the Computing Programme to enhance students' practical research ability [11]. A summer research exchange programme is organised every year to give students the opportunities to participate in research activities in other institutions for enhancement of both academic and research capabilities. With the learning experience gained and knowledge acquired via this exchange programme, these students serve as student mentors, cultivating their peer's devotion to and engagement in research. Table I shows a list of projects led by these student mentors in the past three years.

TABLE I. PROJECTS LED BY STUDENT MENTORS

Year	2018	2019	2020
1	First-person shooter game	Endless Runner game	Running Game (13 students)
2	A Map Application using Google Maps API	A Machine Translation Application using Baidu Translation API	Video Content Moderation using Neural Networks (8 students)
3	Poker Hands Recognition using Neural Networks	Object Detection using TensorFlow	Autopilot in Your Computer (4 students)

Despite class suspension, the student mentorship and relevant project supervision continued using online means. This was to alleviate possible feelings of isolation when the students stayed home for most of the time. This year, 31 students participated in the initial selection process and 25 projects were completed, resulting in an overall completion rate of 80.6%. Among the students qualified for the interviews, 13 are from Year 1, 8 are from Year 2, and 4 are from Year 4. The results of the interview would be used as selection of candidates for the summer exchange programme. Interviews were conducted via video-conferencing to ask the students about their work in terms of the technical components and the management. It was found that their motivation and attitude towards the project were unaffected by the pandemic. Rather, students devoted extra effort to cope with and resolve the problems arising from the research process. Their levels of engagement, understanding and self-learning ability were evidenced from the quality of their work.

V. ASSESSMENT

In consideration of the pandemic development, online assessment was adopted at the Computing Programme in line with the online teaching and learning practices. Generally, module assessment involves continuous assessment (e.g. assignments, projects, tests, quizzes, etc.) and one written examination. Despite the means of assessment, it is necessary to ensure that students' learning performance can be assessed and differentiated. In terms of assessment design, in addition to the academic aspect, particular consideration should be given to the changes brought by the pandemic to students as well as corresponding impact on learning performance and effect (e.g. the sense of isolation, depression and stress). To help students manage these impacts, assessment activities were designed following a progressive approach. Assignments which did not contribute to the final grades were given to students at the beginning of the online teaching and learning process as aids to knowledge acquisition. The level of difficulties of the assignments increased gradually as the module progressed, which finally led to graded assessment activities.

In place of a proctored, in-hall examinations, an online examination was conducted via LMS following the procedures as described below. Students were first informed of the procedures ahead of the examination. On the examination day, an encrypted examination paper was distributed on the LMS, which students may download beforehand and open with a password provided at the time of the examination. Students were required to handwrite the answers and upload the digital pictures of the handwritten answers to the LMS before end of the examination. The entire process was tracked on the LMS, which can serve as records for auditing purposes. In addition, instructors may shortlist students for verbal examinations where necessary after marking. The goal is to ensure a smooth and fair examination while avoiding any possible interruption caused by network connection.

VI. EVALUATION OF EFFECTIVENESS

The effectiveness of online teaching and learning was evaluated in terms of instructor participation and student participation, which are fundamental to sustain the quality of education provision. Two types of survey have been conducted for instructor and student.

An instructor survey was conducted every week to solicit data regarding the type(s) of teaching materials provided to students, the teaching methods adopted, and their evaluation of student participation in order to evaluate the level of participation of the instructors. As shown in Fig. 1, few teachers were able to reformulate their modules at the beginning due to the series of necessary changes to be made to the teaching materials, methods and activities, which were originally to be delivered in brick-and-mortar settings. As the modules progressed, a remarkable upward trend for use of multimedia materials (such as voiceover lecture slides or lecture videos) was observed. This indicated the instructors had gradually adapted to online teaching and learning, taking less efforts in making interactive materials, leading to their more active participation.

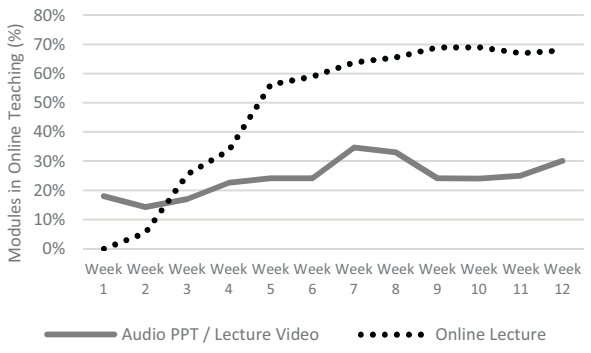

Fig. 1. Online lecture and multimedia materials provided for modules

As classroom teaching is quite different from online teaching, addressing teaching issues in the shift becomes important. Thus, in-depth teacher interviews have been conducted after eight weeks of online teaching. Their comments on teaching method are summarised in Table II.

TABLE II. TEACHERS' COMMENTS ON ONLINE TEACHING

	Advantages	Disadvantages
Progress of Teaching	Recorded lecture and discussion are not limited by time and place	Student engagement may be an issue; Students' feedback is not immediate; Missing students are hard to catch
Materials Prepared	Interactive materials and additional materials help in explanation	Takes time to revise materials

Teachers tended to find more time and room available for teaching and discussion with students. Recorded lectures allow students to review difficult topics. Interactive materials, supplemented with additional materials, make the topics more easily understandable. While student feedback can be obtained via discussion forum or messaging tools, it would be hard to get immediate feedbacks from passive, discouraged students. Student engagement is thus worth particular attention.

As for student participation during the pandemic, it was not mandatory for students to attend learning activities. Student attendance, in this case, revealed to certain extent their attitude towards their studies. Fig. 2 presents an overall picture of students' weekly participation . In the final four weeks, it can be seen that the number of modules in which 61-80% of students particiated was rising while those attended by less than 20% of students dropping. Studies found that Asian students tended to be more passive in their learning style [12][13]. This is a possible explanation for the relatively slow start, particularly in view of the learning atmosphere at home which tend to be more relaxing. Once the adaptation process was completed, students tended to be more engaged in their study.

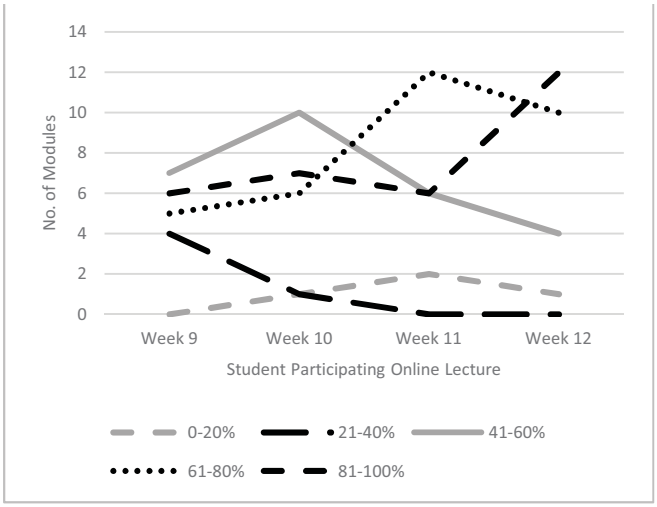

Fig. 2. Student participation based on teacher observation

As revealed in student interviews (summarised in Table III), students tended to find plenty of time available for self-study after online lectures. Senior students tended to report their pace of study can be controlled and progress maintained steadily, with their self-regulation and time management skills enhanced during the process. Some noted the importance of instructor presence no matter in email or in discussion forums, which allowed them to resolve doubts and queries. The students, nevertheless, expressed their preference for face-to-face teaching and learning, which they would not be lagged behind so easily as compared in the online environments. As for the learning materials, the students expressed their preference for multimedia materials as provided during online distance learning over static lecture slides which are often used in brick-and-mortar settings as they can watch or listen to instructors' explanations as many times as deemed necessary.

TABLE III. STUDENTS' COMMENTS ON ONLINE TEACHING

	Advantages	Disadvantages
Progress of Study	Plenty of time for self-study; Control pace of study; Self-discipline and time management skills are trained;	Hard to concentrate at home; Lags behind easily;
Materials Provided	Materials with explanation is more readable; Consultation is important;	Theoretical topics need practical examples;

Assessment was completed within the normal duration of a semester and passed both the internal and external moderation. The mark distribution showed similar learning performance as before the shift to online learning.

VII. RECOMMENDATIONS

For students accustomed to learning in brick-and-mortar settings, the adaptation to online learning environments involves significant changes to their learning style. This could be particularly harsh for Asian students found to be relatively passive. After the shift of learning environments, some students showed efficient adjustment to their learning styles and consequent active learning behaviours while the rest felt discouraged to varying extent in terms of self-regulation and time management. As illustrated in Fig. 3, students reacted to the shift along the continuum between being discouraged and proactive. Pastoral support to passive students is then essential to maintain their learning motivation and engagement.

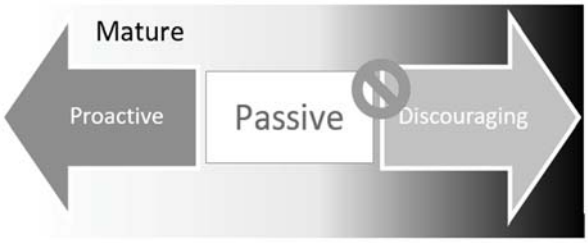

Fig. 3. Consequence of shifting the learning style for Chinese students

In addition, adjustments to module delivery and assessment methods are highly recommended. For module delivery, incorporating interactive elements to teaching

materials and delivery methods should be considered if immediate resources (such as time, skills, and technology) are available in order to avoid exacerbation of the adaptation issue stated above. Creating interactive materials within a short timespan to explain concepts or examples requires technological expertise. Technical support in this regard is thus recommended to bridge the potential gap bewteen technical proficiencies and requirements. Besides, teaching via video-conferencing may help call students' attention with a tablet computer being used as a whiteboard. Despite the screen size, it enables the use of illustrations in the lectures. All these may facilitate effective online learning during the shift if applying appropriately, provided that modules (such as, teaching practice, Internship, Projects, etc.) do not require hand-on exercises. For the assessment methods, assessment activities can be designed following a progressive approach to help students manage their schedule. Assignments which do not contribute to the final grades are given to students at the beginning of the online teaching and learning process as aids to knowledge acquisition. The level of difficulties of the assignments should then be increased gradually as the module progresses.

VIII. Conclusion

This paper presented a case study on an agile shift from brick-and-mortar to online distance learning as a measure to sustain teaching and learning in higher education in response to the interruption and impact brought by the outbreak of Novel Coronavirus Pneumonia (COVID-19) to the society. This case study provided a practical example demonstrating possible practices that can be adopted to deliver different types of modules and carry out assessment under force majeure circumstances. Our approaches have taken into consideration the different needs of taught and non-taught modules, robustness of online assessment, and quick orientation for students who were unfamiliar with online education. The consequent effectiveness of teaching and learning was evaluated in terms of instructor participation and student participation. The findings indicated a relatively slow start due to the series of necessary adjustments to be made to encounter the shift. Once the adaptation process was completed, both instructors and students showed significant changes in their level of engagement in various online teaching and learning practices. Our study highlighted the importance of pastoral support to maintain student motivation and engagement. In addition, adjustments to module delivery and assessment methods are highly recommended.

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