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ORIGINAL RESEARCH

Towards Post-pandemic Transformative Teaching and Learning

Case Studies of Microlearning Implementations in two Post-secondary Educational Institutions

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Abstract
The recent COVID-19 pandemic has presented challenges to post-secondary education, including that campuses have been closed, removing face-to-face instruction options. Meanwhile, this crisis has also presented unique opportunities to create a "tipping point" or conditions that foster innovative teaching practices. In light of such a "danger-opportunity," the feasibility of introducing microlearning (ML), a technology-mediated teaching and learning (T&L) strategy, has recently been revisited by some institutions. ML offers learning opportunities through small bursts of training materials that learners can comprehend in a short time, according to their preferred schedule and location. Initially considered as "add-on" complementary online learning resources to provide learners with an active and more engaging learning experience through flexible learning modes, the possibility of an institution-wide implementation of ML has been further explored during the COVID-19 lockdown. This paper presents an exploratory case study examining two post-secondary education institutions' ML introductions. Using the SAMR model as the lens, their approaches to adopting ML are examined through analysis of quantitative questionnaires and qualitative teacher reflections. Overall, ML appears to be a promising direction that may not only be able to help institutions survive, but possibly offer an enhanced teaching and learning experience, post-pandemic. However, its current implementations face many challenges, both practical and pedagogical, and their impacts have yet to achieve transformation. With the insights gained, some possible strategies for moving the adoption of ML to the next level are offered.

Keywords Microlearning (ML) · Innovation implementation · Education change · COVID-19 outbreak · SAMR

Introduction

A Reality of Post-secondary Education During the COVID-19 Pandemic

The COVID-19 pandemic has created an unprecedented health and economic crisis [1], disrupting the learning opportunities of many individuals. In response to COVID-19, confinement measures were taken—most post-secondary education institutions had to close their campuses, temporarily removing the options of any face-to-face teaching and learning (T&L) activities.

While institutions have been dealing with the academic, financial, and logistical challenges and uncertainties caused by the pandemic, they, at the same time, have raced to identify workable solutions to ensure the continuity of learning. Online T&L methods, particularly video-based solutions, have quickly become the most sought-after alternative to in-person instruction [2].

On one hand, the forced reality of moving online to ensure T&L continuity appears to have tremendously accelerated the mainstreaming progress of technology-enhanced T&L, a new paradigm that is often perceived as challenging for many. On top of the physical infrastructure, the effectiveness of online T&L adoption is still conditioned by low

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levels of preparedness from various perspectives—teachers and students alike have had to make considerable efforts to adjust. Moreover, one of the commonly perceived bottlenecks for post-secondary education institutions to move entirely online is its conventional teaching practices. For many disciplines, the predominant delivery approaches have been rooted in skills development for specific professions, which can require a large number of demonstrations, exercises, and interactivity to suit particular needs [3].

On the other hand, this crisis has also presented unique opportunities to create a “tipping point” [4], or conditions that foster innovative teaching practices. It has allowed institutions to revisit strategies to build a transformative learning environment that can cater to (and strengthen) the kind of learning and agility needed for the knowledge economy [5].

Microlearning as a T&L Strategic Response to the COVID-19 Situation

There are many ways to reorient education to an online format and address the current T&L needs. One of the promising directions being explored is the introduction of Microlearning (ML).

Although there is no consensus on the definition of ML as a teaching method [6], it has been identified as involving putting knowledge into episodic, manageable, readily attainable bursts for learners to consume [7]. Hug[8] characterized the essence of ML across seven dimensions: (1) requiring a short-time engagement; (2) carrying less content; (3) potentially being drawn from course elements; (4) scattered form; (5) coherent and self-contained; (6) media-rich; and (7) supportive of various learning approaches.

The emergence of ML is associated with the fast-moving nature and fragmentation of knowledge today. As Langreiter and Bolka [9, p. 79] described, ML “reflects the emerging reality of the ever-increasing fragmentation of both information sources and information units used for learning, especially in fast-moving areas which see rapid development and a constantly high degree of change.”

One of the theoretical propositions behind ML is the cognitive load theory (CLT), according to which, students may experience a cognitive overload because of their limited capacity to process amounts of material at one time [10]: when information is sliced into frequent ML opportunities, the cognitive load can be significantly reduced [11].

A variety of ML approaches have been explored by education researchers and practitioners in recent years. An example of ML content could be in the form of a video presentation, audio or screen recording, or even a PowerPoint slide showing a single and focused topic. Pedagogically, microcontent (the content in ML) can be made for flipped classrooms and can provide re-enforcement for student learning [12]. Instead of delivering a lecture in a single, long, class presentation, the lesson material can be divided into sub-module parts (sub-topics or “chunks”), which the learners can access at their own pace through online platforms such as Learning Management Systems (LMSs). ML can quickly provide learners with required knowledge and skills [13]. Although often used for formal curricula and highly specified learning objectives, ML can happen informally [14]. It can occur between other activities, on the move, during waiting moments—often driven by knowledge needs or inner impulses. Such impulses may be supported, or even triggered, by an ML system using learning pushes as a teaser to attract attention or raise interest for students’ self-regulated learning [15].

Several benefits of using ML have been reported in the literature, including: (1) greater retention of concepts [16, 17]; (2) better engagement for learners [18, 19]; (3) improving learners’ motivation [20]; (4) engaging in collaborative learning [21]; and (5) improving learning ability and performance [22]. ML, like any other technology-mediated T&L strategies, also has its pitfalls. In addition to the lack of definitional consensus mentioned earlier, its applicability (and possible misuse) has been questioned. Jomah et al. [23, p.104], for example, challenged that “micro-learning is NOT useful when people need to acquire/learn complex skills, processes, or behaviors.” Such a contradicting reality calls for further research. Furthermore, this new concept still lacks a solid empirical basis, including an evaluation of its impact during the COVID-19 crisis.

SAMR Model as an Evaluation Framework of EduTech Impact

SAMR stands for Substitution, Augmentation, Modification, and Redefinition. Represented as a four-level taxonomy (See Fig. 1), SAMR is a model that describes the impact technology has on T&L. According to its originator [24], the SAMR model was designed as a tool to plan, implement, and evaluate technology use in education settings.

At the Substitution level, technology is substituted for the traditional method, but the substitution generates no functional change. At the Augmentation level, technology is exchanged, and the function of the task or tool changes positively, in some way. At the Modification level, technology integration allows for a redesign of the task. The Redefinition level is achieved when technology is used to create novel tasks that were not previously possible. Learning activities that fall within the Substitution and Augmentation classifications are said to enhance learning, while learning activities that fall within the modification and redefinition categories are said to *transform* it [25]. Puentedura [25] encourages teachers to move up from lower to higher levels of teaching with technology in SAMR, as such a shift can lead to transformative T&L.

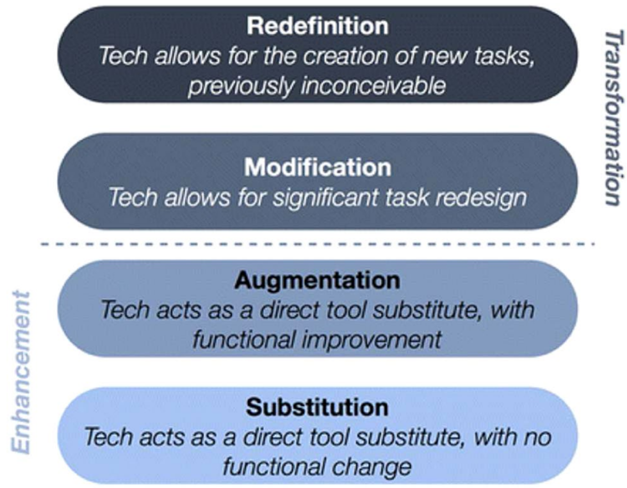

Fig. 1 The SAMR model [24]

The SAMR model provided us with a lens through which to examine the introduction of ML, and therefore served as the conceptual framework that guided this study.

Our Study

This paper reports on an ongoing research investigation examining the approaches taken by two institutions—a Hong Kong technical and vocational education and training institution (hereafter, TVET-A) and a Sino-foreign higher education institution (hereafter, HEI-A)—to the introduction of ML during the COVID-19 outbreak. Members of our research team were directly involved in the ML introductions at both TVET-A and HEI-A. Their access made the two institutions ideal cases for examining ML impacts—effectively, a convenience sampling method was employed, although the nature of our investigation was inductive.

As exploratory case studies [26], we attempted to answer the following two questions:

1. How was ML implemented in the selected institutions?
2. How did the introduction of ML impact T&L in the selected institutions?

Because the introduction of ML was an implementation of change in education and learning environments [27], we followed emergent design [28] when conducting our case studies. As our investigation evolved, a consensus was reached among the researchers that the primary data source would be the post-course evaluation questionnaires at the two institutions. The information gathered was supplemented or triangulated using researchers' observations and several just-in-time, unstructured follow-up interviews. The ongoing reassessment of data collection not only allowed the researchers to be more responsive to information and insights learned, but also added to the richness when portraying the cases.

With the insights gained from the answers to the research questions, we reflected upon the promising practices, lessons learned, opportunities, and challenges for introducing ML in post-secondary education. We also attempted to generate some possible strategies that may help post-secondary education institutions to fully take advantage of the opportunities, and to address the challenges for implementation.

Preliminary Findings

Case I: TVET-A

In TVET-A, the ML initiative was piloted in 2015 with selected courses, aiming to provide learners with an active and more engaging learning experience through flexible learning modes. The initiative also aimed to help develop lifelong learners who could respond to evolving societal needs and community demands. As a pilot implementation, ML lessons were focused on the engineering discipline as a way to support students mastering the content alongside their practicum practices. Since the COVID-19 outbreak, the possibility of an institution-wide implementation of ML has been further explored.

Analysis of the TVET-A case suggests that their ML primarily served in a Substitution role, as described in the SAMR model (Sect. "SAMR Model as an Evaluation Framework of EduTech Impact"). Instead of a redesign of T&L, ML was offered mostly as an "add-on", complementary resource. The overall agenda of adopting online ML materials at TVET-A was, as our further investigation revealed, mainly to provide just-in-time information for TVET students at workshops and workplaces, and to enable them to retrieve basic know-how, procedures, or regulations while engaging in their practice. Because of this, the impact achieved was admittedly still at the very surface level.

Our evaluation of TVET-A's ML being at Substitution stage was also informed through analysis of a student questionnaire that gathered TVET-A Engineering students' (n = 496) user experience of the ML lesson. The questionnaire consisted of 13 closed-ended questions covering six themes: (1) accessibility; (2) layout and interface; (3) learning and teaching design; (4) learning outcomes; and (5) overall quality. Students were asked to rate according to a 6-point Likert scale, with "1" being "Strongly Disagree" and "6" being "Strongly Agree." The use of an even-point scale eliminated responses falling in the middle (neutral), which avoided ratings that did not contribute to the survey in a significant way, forcing students to make a decision on their opinion. At the end of the questionnaire, three open-ended, qualitative questions were also asked. Responses showed that the "accessibility" of the ML lesson was favoured by over half of the students (55%), who agreed that the platform was user-friendly. However, only 36% of the students reported being satisfied with the "layout and interface." With a positive response of 64%, the "learning and teaching design" was considered appropriate and adequate. 50% of the students reported finding the "learning outcomes" barely satisfactory. The overall quality was rated 50%, with half of the students reporting that their practical skills were improved upon completing the ML lesson.

Some of the qualitative feedback included:

- The duration of this lesson was just right.
- I was able to access the lesson easily.
- I was able to access the videos without much difficulty.
- The all-time accessibility was convenient for my learning.
- The learning objectives were clearly stated in each video.
- The learning contents in each video were well structured.
- The learning content was effectively presented and explained clearly.
- The lesson was best for the demonstration of practical skills and theories.
- The lesson presented the subject in interesting ways. My overall knowledge of this subject was enriched after taking this lesson.
- My practical skill in this subject was improved after taking this lesson.
- This lesson motivated me to learn.
- Overall, I had a good learning experience in this lesson.

As a pilot lesson, it was encouraging to see students' tendency to use ML to support learning. In particular, students reported finding the ML content easy to digest, and reported improving their practical skills by repeatedly reviewing the procedures and techniques—the microcontent was short enough for learners to consume easily, in one go, and was available to learners whenever they needed. As supplementary online learning resources, the ML lesson was a good start, with satisfactory results.

However, it was also stressed that online learning could not fully replace the face-to-face lessons, partly because the ML content was too general for students to be able to delve into the details of the topics. The learning content could stimulate self-study, but appeared to really only be beneficial to students at the beginner level. There was a lack of interaction with teachers and peers, and no instant response could be offered to students when they encountered difficulties in learning. In response to this, it was suggested that a discussion forum be added as a communication channel.

Case II: HEI-A

In HEI-A, ML was informally piloted during the online T&L phase in the second semester of 2019–20. ML was implemented in a fundamental class focusing on teaching perspective-sketching and marker-rendering techniques relevant to the product design industry. Before the COVID-19 lockdown, the course was taught face-to-face, using live demonstrations, examples, and lectures to present each technique to students. It was assessed through in-class tests. There were three classes per week: the first class introduced the technique and the requirements for the in-class test. This was followed by a live demonstration. The following class had a second live demonstration with additional information related to the test requirements. Towards the end of this class, depending on time constraints, there would normally be an opportunity for Q&A and feedback. In the final class each week, students completed the in-class test. This format was repeated each week.

One reported issue with this arrangement was that, as the sketching and rendering techniques became more complex over the course of the academic year, the duration of the live demonstrations increased, and the time available for Q&A and feedback deceased (sometimes to a point of there being no time at all for Q&A and feedback). Additionally, due to the time constraints, the live demonstrations were often basic or introductory, and rarely in-depth or applied in more advanced contexts.

With these issues in mind, ML was introduced as a supplementary online learning resource, in the form of a video library, accessible through HEI-A's LMS, Moodle [29]. The videos were categorised according to test or technique. Each technique was broken down into several short video demonstrations (each about 5–7 min long), focusing on a single aspect of the technique, and culminating with a small related task. The online learning resource was utilised in a flipped class manner [30] and substituted for the lengthy live demonstrations: This allowed for new possibilities during the demonstration classes that were not previously feasible. The online learning resource contained in-depth explanations and demonstrations, and concrete examples with links to real-world applications. Students watched the videos and completed the tasks after the previous in-class test, and before the next demonstration. The implications of the supplementary online learning resource meant that students had a basic understanding, and had attempted a related task, before the technique was formally introduced: This allowed for a more in-depth introduction, and for more focused demonstrations and practical activities (using real world examples) during the class time. Additionally, this change allowed students to practice the techniques under teachers' supervision, and to receive direct feedback, thereby using the class time more effectively, and enabling more time for Q&A.

This intervention also changed the dynamic of the class from "demonstrative" and "teacher-centric" to a more practical and "student-centred" learning model. From the teacher's perspective, this created a positive learning environment with more confident and empowered students in the classroom. It has enabled more opportunities for teacher–student interactions, through the direct feedback opportunities, and increased both the Q&A time and the practical activities.

After the introduction of ML, the average student mark increased from 64% in the previous year to 73%, with more students than ever receiving a final mark of over 80%. HEI-A's "Student Evaluation of Module" surveys reported students being more satisfied with the class than ever before, giving an overall satisfaction rating of over 90%. This highlighted that, regardless of the learning environment (lockdown/remote T&L), high-quality T&L can be maintained. The following are some student comments on the class:

– The course contents are covered in detail and enrich my understanding of sketch and rendering skills.
– Lot of explanation of the knowledge is on the Moodle.
– The online videos are great, I can re-watch them multiple times, which makes it easier to understand.
– Prefer online demonstrations, because I pay more attention to the detail and improve the quality of my sketches.
– Perfect module! Online teaching is great.

The above-described implementations revealed that the ML intervention impacted HEI-A at the "Redefinition" level in the SAMR model, transforming the teaching structure, enhancing T&L methods, and creating new learning experiences that would not have been possible without the addition of technology and ML. HEI-A's ML implementation changed the class structure towards a flipped learning model; provided new opportunities during the class time, such as the practical activities and supervised practice; and altered the dynamics of the class from teacher-centric to student-centred.

After seeing the positive impact of ML in the sketching and rendering class, HEI-A is now keen to explore the potential of implementing ML in other areas, such as the core design project classes within the programme.

Discussion and Implications for Practice

As impacts of the COVID-19 pandemic continue, worldwide, and uncertainties remain, it is perhaps an opportune moment for post-secondary education institutions to consider a paradigm shift for post-pandemic education. Given this ongoing study's preliminary findings, which confirm many benefits discussed in the literature (e.g., Major and Calandrino [11], De Gagne et al. [18], Nikou [19], Nikou and Economides [20]), we agree that ML appears to be a very promising direction. Also, contrary to some previous claims (such as by Jomah et al. [23]), skill-based courses like those at our TVET-A and HEI-A case studies, may be facilitated effectively, if an appropriate learning design is used.

The positive feedback illustrated how the threat posed by a crisis like COVID-19 could be turned into an opportunity: Campus closures made online T&L an indispensable response, thus removing many system-level constraints (such as policy issues) previously seen to hinder online adoptions.

While it was acknowledged that ML, in its current form, could not fully replace the face-to-face T&L, institutions need to reflect on how to ensure ML can offer the same quality and engagement as face-to-face teaching, even when only impacting at the Substitution level. One focus area may include examining how to improve interactivity. After all, content does not become more appealing by simply breaking it into smaller pieces. Greater interactivity of ML can perhaps compensate the missing teacher–student dynamic when the classroom option is removed.

There is no denying that the short-term focus in the face of COVID-19 has still prioritised continuity of learning and making resources available, as was seen in the promising practices at TVET-A. We must recognize that this is not a full realisation of all of ML's opportunities and potential: Substitution- and Augmentation- oriented use only represent the lower half of the SAMR model. ML's true potential lies in impacting education at transformation levels (SAMR's Modification and Redefinition). Transformative ML use would further support students becoming more independent learners, helping them to engage more with the learning process. For this to succeed, the curriculum and ML activities must be reviewed; and the pedagogy should be revisited, to ensure a good alignment. Teaching staff's capacity to adopt ML will need to be built, so that they can make ML-responsive curricular and pedagogical decisions.

As highlighted in the HEI-A study, ML was able to transform the class structure, empower learners, and provide new opportunities. Starting to apply ML progressively towards the Redefinition level meant that HEI-A was able to quickly benefit from ML, without a radical restructuring of the original content. Additionally, HEI-A's practice demonstrated a promising direction of ML's effective use towards Transformation: by utilising ML in a flipped manner, basic introductory and fundamental information was covered beforehand, allowing for the class time to be more focused on practical exercises, advanced application, and student feedback. This, in turn, from the teachers' perspective, created more informed and confident students, and allowed for more practical activities within the classroom, which helped to reinforce learning.

The lessons learned from these discussions have allowed us to further reflect upon how institutions could fully take advantage of the ML opportunities, and address the implementation challenges. We suggest the following strategies.

1. ***Institutions should continue development of ML content***. Keeping the practice sustainable, even post-COVID-19, may be beneficial for the institution from multiple perspectives. Academically, it is an opportunity for curriculum review and revision, with the potential to redesign to a more flexible and blended format [31, 32]. Following the principles of the SAMR model, educators are encouraged to move from lower to higher levels of teaching with technology: Institutions could begin by implementing ML as supplementary content, to support and scaffold learning, as shown in the HEI-A case. A flipped-learning approach [30, 33] could allow the independent study of the content-based knowledge while maintaining hands-on skill-based practice. Furthermore, from an administrative perspective, incorporating ML (with the lessons learned from the COVID-19 pandemic) could enable a more efficient response to future unexpected events.
2. ***To further enrich ML resources, incorporation of Open Educational Resources (OERs) should be encouraged***. Often carrying the Creative Commons Attribution Only (CC BY) or a GNU license, OERs allow users to freely retain, reuse, revise, remix, and redistribute the learning resources, all within the framework of intellectual property rights and fully acknowledged authorship [34]. Because of this nature of OERs, their incorporation may ease the microcontent development challenges: If existing OER content can be adapted to meet the needs for ML, there is no need to "reinvent the wheel."
3. ***Institutions should invest more in immersive technologies, such as virtual reality (VR) and augmented reality (AR), in conjunction with ML***. Given the skills development nature of many disciplines (including those in the TVET-A and HEI-A engineering programmes), AR/VR ML technologies, with their proven application in military and medical training [35, 36], could strongly supplement the learning experience.
4. ***Building the capacity of instructors, especially their Technological Pedagogical Content Knowledge (TPACK), is necessary to ensure effective ML use***. For capacity-building [37, 38] measures to be effective, they cannot only focus on mastery of the related technical knowledge: Instructors need convincing evidence, and examples, about how well ML could effectively support their T&L practices … and they need this before they embrace any new technology [39, 40]. One approach to achieving this would be through capacity-building activities that showcase promising practices, and that suggest pedagogies that work well with ML.
5. ***Institutions should regularly collect student feedback on their ML experiences***. These snapshots can serve as a more valid reference for monitoring and reviewing institutions' ML implementation strategies. This, subsequently, can help the institution to tackle the issues that hinder transformative use of ML from the end-user prospective.

Concluding Remarks

This exploratory case study has examined two post-secondary education institutions' ML introductions. Using the SAMR model as the lens, their approaches to adopting ML have been examined. We found that ML appears to be a promising direction that may not only be able to help institutions survive, but may also support a possible paradigm shift that will enhance teaching and learning experiences. Because current ML implementations face many challenges, and their impacts have yet to achieve transformation, institutions will need new strategies to move the adoption of ML to the next level. We have identified and offered some such strategies, based on the promising practices and lessons learned from our two cases. We believe that when these strategies are considered, the challenges of current ML implementations could be addressed, and the opportunities afforded by this new learning modality could be more fully realised.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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