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Effective digital learning practices for IS design courses during COVID-19

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Completed Research

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Abstract

The COVID-19 pandemic has pushed educational institutions to adopt digital learning for an extended period. This research studies the effectiveness of digital learning practices based on student feedback data collected for two Information Systems design courses: human interaction design and solution architecture design. This paper leverages the data to analyze the effectiveness of a set of digital learning practices: ZOOM lectures, polling or Kahoot questions, self-reflection, virtual exercises and virtual mentorship. Our research questions are on the effectiveness of these learning practices to keep the student's interest and learn the course materials. The research compares each learning practice and the overall learning experience compared to face-to-face. Our result shows that polling or Kahoot questions are the best digital learning practice to keep students interested and learn content. Mentorship works well to keep student interest, while ZOOM lectures and virtual exercises work well for the student to learn content.

Keywords

Digital learning practices, Information Systems design courses, COVID-19, effective learning practices, learning activities, face to face, online and blended learning.

Introduction

Many Information System (IS) courses require students to make design decisions based on abstract design concepts. For undergraduates who have experienced programming to give deterministic outcome during development, the ability to trade-off design elements to reach a justifiable design decision can be challenging. For IS undergraduates with limited working experiences, initial guidance is critical for appreciating abstract design concepts. The work by Rupakheti (2015) and Ouh (2019; 2020) describes the challenges in teaching software architecture design courses to undergraduates. Teaching design concepts to undergraduates involves a mindset switch for the students and require much guidance from the instructor. Learning practices/activities that involve extensive face-to-face (F2F) guidance are designed to help these students before the COVID-19 pandemic (Chi 2009; Gan et al. 2015; Gan and Ouh 2019; Sivilotti and Pike 2007). When COVID-19 successfully forced a global shutdown of F2F activities in many sectors, including education, it is no longer an option but a necessity for universities to migrate to digital learning. It is evident that emergency remote teaching with little time to design effectively become a challenge (Adedoyin and Soykan 2020; Adnan and Kainat 2020; Ni 2013; Schultz and DeMers 2020; Soffer and Nachmias 2018). As we understand and improve the digital learning practices, they can help us adapt to the new post-COVID future of online and blended learning everywhere (Kintu et al. 2017; Lockee 2021; Philipsen et al. 2019).

In this study, we evaluate the effectiveness of our digital learning practices for two of our IS courses: human interaction design and solution architecture design. We had applied some of these learning practices as blended learning before. However, this time, these learning practices are re-designed for online over the summer months and applied for an entire semester without F2F guidance.

In this study, we address the following research questions.

RQ1 How effective are these digital learning practices to keep student interest in the course topics?

RQ2 How effective are these digital learning practices for students to learn the course materials?

RQ3 What is student overall digital learning experience?

We first describe the related works and the set of learning practices. The paper continues with our research method, our results and possible threats to the validity of our results. Finally, we summarize and conclude our study.

Related Work

Designing learning practices/activities for face-to-face (F2F) information systems courses are described in studies by Chi (2009), Gan (2019) and Sivilotti (2007). Chi defines learner-centered activities as active, constructive and interactive activities. Active activities are those that basically engage the learners' attention, such as focusing or gazing upon some aspects of the learning material, repeating the materials, or manually manipulating the presented learning materials. Constructive activities are those that require learners to produce some outputs, which may contain some new ideas, such as in self-explaining, drawing a concept map, or inducing hypotheses, and reflecting. Interactive activities involve participating in two kinds of dialogue patterns, either with experts (instructional dialogues) or with peers (joint dialogues). Within instructional dialogues, learners could be participating in guided-construction activities (e.g., respond to scaffoldings & hints, revise errors from corrective feedback); and within joint dialogues, learners could be participating in sequential-construction or concurrent-construction activities (e.g., build and elaborate on a partner's contributions, argue and defend a position, criticize partner's contribution). Chi hypothesized that interactive activities are most likely better than constructive activities, which in turn might be better than active activities, which are better than being passive. Gan found that learning activities for design thinking courses took longer time to complete. Thus, it reduces the coverage of learning content. He also found that the level of instructional guidance provided and complexity of the learning content does not significantly correlate to the effectiveness of these learning activities. Sivilotti provided examples of exercises as learning activities for a distributed computing course. He advises that designing these learning activities begins with an explicit learning objective statement. In addition, he suggests designing for an element of surprise, involve multiple dimensions of engagement, anticipate mistakes, engage the entire class and provide simple directions for participants.

Schultz (2020) describes that the Covid-19 pandemic precipitated a triage-like environment wherein experienced faculty were forced to convert courses rapidly to online venues. Design for success in a digital environment involves substantially more planning than teaching the F2F environment. Given enough time to design an online course, we refer to the following study comparisons. Soffer (2018) did a quantitative study that compares three online courses with the same three F2F courses. Soffer finds that students in the online courses reported better understanding of the course structure, better communication with course staff, and higher engagement and satisfaction. Ni (2013) compares online and classroom learning effectiveness in a public administration class. The results of this study focus on the student's learning experiences. It indicates that although student performance is independent of instruction mode, participation may be less intimidating, and the quality and quantity of interaction may be increased in online classes. Soffer and Ni found benefits in well prepared online courses.

Adnan (2020) study examines digital learning in Pakistan during Covid-19. His research shows that online learning cannot produce desired results in underdeveloped countries like Pakistan, where a vast majority of students are unable to access the internet due to technical as well as monetary issues. The lack of F2F interaction with the instructor, response time and absence of traditional classroom socialization were among issues highlighted by students. Adedoyin (2020) discusses the challenges and opportunities for digital learning during COVID-19. The challenges are that pandemic-related anxiety will have negative effects on student academic performance; there are racial, economic and resource differences; and most instructors are not effectively ready to deliver high-quality instruction remotely. The opportunities are the increased University adoption of digital learning to take advantage of the benefits in flexibility, interactivity, and self-pacing. Adnan and Adedoyin found drawbacks in Covid-19 ill-prepared digital learning.

The foundation is set for a post-Covid future with online and blended learning classrooms everywhere. Kintu (2017) investigate the effectiveness of blended learning, a mixture of F2F and online, to determine

significant predictors. He found that student characteristics and digital learning design features are significant predictors for student learning outcomes. Student characteristics such as attitudes and self-regulation predict their acceptability of digital learning. Design features such as technology quality, online tools and F2F support predicts intrinsic motivation for digital learning. These are important considerations when we move into a post-Covid blended learning future. One of the main educational challenge of this Covid-19 pandemic as described by Adedoyin (2020) is how educators are not effectively ready to deliver high quality instruction remotely. Philipsen (2019) studied 15 articles on teacher professional development (TPD) strategies that targets online and blended learning (OBL). He identified 6 important components of TPD for OBL: design and development of a supportive TPD for OBL program and environment; the acknowledgement of the existing context towards OBL; the addressing of teacher change associated with the transition to OBL; the determination of the overall goals and relevance of TPD for OBL; the acknowledgement of TPD strategies associated with the change to OBL; the evaluation of the TPD and the dissemination of the knowledge, skills, and attitudes. However, Lockee (2021) points out a potential limitation of Philipsen's framework study is that TPD for OBL needs may currently differ, as teachers are experiencing appreciably different learning and performance contexts related to the mandated shift in professional practice to address continuity of instruction.

Digital Learning Practices

Before the COVID-19 pandemic, our classes were conducted in three-hour F2F sessions in a seminar-style classroom of around 45 students. This session comprises of lectures and other learning practices to be described in the following sub-sections. During the COVID-19 pandemic, our educational institute mandate courses to be delivered online and we have about two to three months to design the online course. We narrowed the lecture delivery platform to ZOOM, WebEx or Microsoft Teams. We decided to use ZOOM based on the more user-friendly interface.

Online Lecture Practice

Lectures account for about half of each session to deliver the course content and allow student participation. Students participating during lecture would be classified as an active learning practice according to Chi's definition (Chi 2009). The learning outcome is for the student to understand key learning content such as solution architecture patterns, qualitative architecture attributes, empathizing with user, prototyping and user testing.

Students were given a pre-scheduled ZOOM meeting room. Upon validation, they enter the meeting room where we conduct our lesson. ZOOM allows our class of 45 to interact in the main meeting room with breakout rooms for group discussions. Slide presentations and videos are shared throughout the lecture. Students are encouraged to virtually raise their hand or type in the chat room to clarify doubts and participate in discussions. Students may mute/unmute and/or switch on/off their video to participate or present. In a F2F classroom, the instructor can easily interact with students by monitoring their expressions and movements. However, in a ZOOM meeting, the instructor must be more patient and pause longer for students to speak online. The name tags on student video make it easier to identify students. However, the limited screen size makes it harder to get class feedback on a topic compares to F2F classroom interaction. Some students have internet connectivity or audio/video equipment problems.

The lectures are recorded for students to review after the class. We realize it is also essential to consolidate and centralize access to online materials to allow straightforward and consistent access. Students can be distracted and are lost in the lesson flow. In a F2F classroom, they are able to seek help quickly by monitoring others in the classroom. However, this is much harder during digital learning. Having a consistent repository allows the student to refer to content at their own pace. With fewer F2F interactions, collaboration features in online tools such as Google Drive and GitHub are now even more critical for effective communication.

Question Practice

We post a set of revision question designed beforehand by the instructor during the three-hour session. Students answering the questions would be classified as a constructive learning practice according to Chi's definition (Chi 2009). These questions allow each student to test their understanding and is conducted

immediately after the instructor covers the contents or later within the same class session. The instructor can use online tools to allow the students to answer the questions on their online devices or use pen and paper. Before COVID-19, we primarily use Kahoot as a gamification tool to prepare and execute the quiz questions. The entertaining elements provided by these tools, such as music and interactive comments, also helps to smooth the tense situation of taking a quiz. Since we use Zoom as the lecture tool during COVID-19, we also use Zoom polling as another tool for students to work on the questions. Wang (2020) highlighted that a game-based student response system can improve teacher-student interaction, reduce student anxiety related to asking questions and have a positive effect on student's concentration, attention, enjoyment, satisfaction, and confidence.

The Kahoot or Zoom polling learning practice has a time constraint, and students have to decide the answer individually. We tend to extend this time constraint for digital learning as students may encounter slowness in accessing the questions. We conduct this quiz in an anonymous mode to not identify the student directly from the response. We use this method once a week and can be at the start of the lesson to recap previous week content or during the lesson to summarize the contents covered. This learning practice allows the students to validate their understanding and hopefully focus their attention on what they do not know.

Self-Reflection Practice

This learning practice allows the student to reflect on what they learn for a topic covered in a session. Student reflections would be classified as a constructive learning practice according to Chi's definition (Chi 2009). Self-reflection enables students to process what they just read, not through summarization but through application. Rusche (2011) highlighted that critical self-reflection help students to maintain critical engagement with the course materials. The students can send their reflection in an email or fill an online survey of the contents they have learnt. We usually remind the students of the self-reflection survey, and they can take more time to do it after class. The online survey questions are open-ended. They are: "How well did you understand today's materials?" and "What are the important things you learned in class today? If you have doubts about a specific concept/topic/point for the course, please state below." The conduct of this learning practice remains the same before and during COVID-19.

Virtual Exercise Practice

This learning practice allows the student to work on short exercises, either individually or in their teams. We design these exercises for critical thinking and to provide hands-on practice on a particular discussion point. Before the COVID-19 pandemic, this discussion occurs in the seminar room, and instructors hand out exercises to be completed digitally or on paper. Students can gather physically to discuss and present their answers. In solution architecture exercises, students are required to set up physical network equipment, observe the outcomes and explain the findings. In human interaction prototype exercises, students build spaghetti towers in a Marshmallow Challenge. Group exercise would be classified as an interactive learning practice according to Chi's definition (Chi 2009).

During the COVID-19 pandemic, instructors re-design these short exercises due to the lack of F2F interaction and the need to use physical equipment together. Instructors hand out the exercises digitally, and students can only complete them individually. For exercises that require teams to derive an outcome, we use Zoom breakout rooms. However, they are unable to experiment on physical equipment. In this case, we search for online resources to allow teams to work together. For example, instead of setting up a three-tier architecture with physical routers and cables, we use cloud resources to replace the physical equipment in the exercises for the student to configure and achieve the same learning outcomes. However, there are still exercises with no online replacements. The exercise for human interaction design course requires teams to brainstorm and develop a prototype together using a set of physical materials. Due to Covid-19 restrictions, each team member does their prototype separately and convene to decide on the best prototype to present. This is not an ideal environment for brainstorming and prototyping.

Virtual Mentorship Practice

This learning practice involves instructors mentoring the students doing project work that usually takes multiple weeks to complete. The interactions between mentors and students would be classified as an interactive learning practice according to Chi's definition (Chi 2009). Mentorship learning as pedagogy is

mainly applied in professional education and training. However, Arnesson (2017) research results show that mentorship is an important contribution to the learning process for integration of theory and practice in higher education to develop both practically applied and theoretically anchored knowledge.

Online lecture covers theory that can be applied in project assignment. The project assignment in our course takes the form of a series of problem sets that requires the students to discuss as a group and with the instructors to prepare a set of deliverables. Students are required to work in teams of four to six members to complete the project. They are required to present their projects at the end of a milestone. Before the COVID-19 pandemic, teams have physical meetings weekly with their mentors to work on the project. During the COVID-19 pandemic, teams are not allowed to meet physically. All meetings within teams and with mentors are conducted virtually and with the same weekly frequency. We do realize these virtual meetings are more straightforward to arrange due to less travel time. Instructors and students can convene quickly from one meeting to another with few clicks. There are also other online communication channels such as Telegram with the instructors and teaching assistants which students can approach to ask questions.

Research Method

This section explains how we designed our research study involving two Information Systems design courses – human interaction design and solution architecture design. We apply the learning practices described above and conduct the study during the first semester of the academic year 2020-2021 (August to December 2020 period). The human interaction design course is a core module, and we had 387 students. These students are mostly in their second or third year of studies. The solution architecture design course is a track elective, and 48 students took the course that semester.

During the last week of the course, we conducted our survey after receiving Institutional Review Board (IRB) approval. The students were briefed on the survey's purpose and are aware that the survey does not affect their course grade. Survey participation is voluntary, and student can opt out if they wish to do so. We conducted the survey using Google Forms. The four survey questions are

1. How effective are these methods {learning practices} to keep your interest in the course topics?
   [Quantitative – Likert Scale of 1 – 5 with 1 being least and 5 being most effective]
   Please explain your answers. [Qualitative – Free Text]
2. How effective are these methods for you to learn the course materials?
   [Quantitative – Likert Scale of 1 – 5 with 1 being least and 5 being most effective]
   Please explain your answers. [Qualitative – Free Text]
3. What is your overall rating for this course?
   [Options: Very Bad. Bad. Neutral. Good. Excellent]
4. Please compare the online course to your experience with traditional face to face course
   [Options: Online Course is much better. Online Course has some advantages. There are no differences between online and face to face courses. Face to face course has some advantages. Face to face course is much better]

The first two questions focus on the effectiveness of the methods {or learning practices} to keep their interest and learn the course materials. The last two questions focus on the course's overall experiences during the COVID-19 pandemic and compare them with the traditional F2F approach.

Research Result

This section discusses the survey data and findings. We have a total of 138 survey responses. Tables 1-2 and Figures 1-4 shows the responses to the survey questions.

Effectiveness	Online Lecture - Zoom	Questions - Kahoot and Zoom Polling	Virtual Exercises	Self-Reflection	Mentorship	Others (e.g., Telegram)
1 - Least Effective	4	2	5	14	4	12
2	12	13	10	20	6	10

3	24	20	31	33	28	32
4	69	51	60	51	60	56
5 - Most Effective	29	51	32	18	40	22
Overall Avg. Effectiveness	**3.78**	**3.99**	**3.75**	**3.29**	**3.91**	**3.50**

Table 1. Digital Learning Practices to keep student's interest

Effectiveness	Online Lecture - Zoom	Questions - Kahoot and Zoom Polling	Virtual Exercises	Self-Reflection	Mentorship	Others (e.g., Telegram)
1 - Least Effective	1	3	1	19	7	16
2	10	7	8	17	8	9
3	25	23	26	27	23	37
4	60	46	58	46	62	46
5 - Most Effective	41	58	44	24	37	25
Overall Avg. Effectiveness	**3.95**	**4.09**	**3.99**	**3.29**	**3.83**	**3.41**

Table 2. Digital Learning Practices to learn course materials

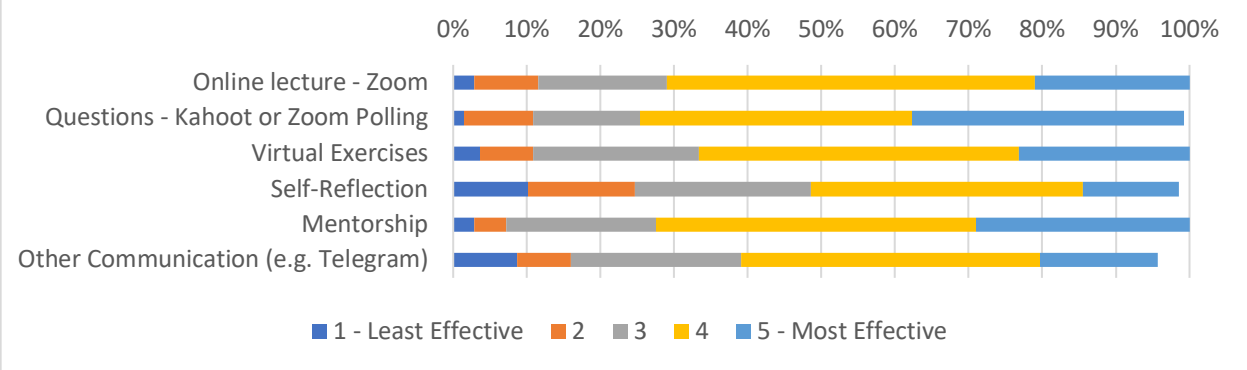

Figure 1. Effectiveness of Digital Learning Practices to keep student's interest

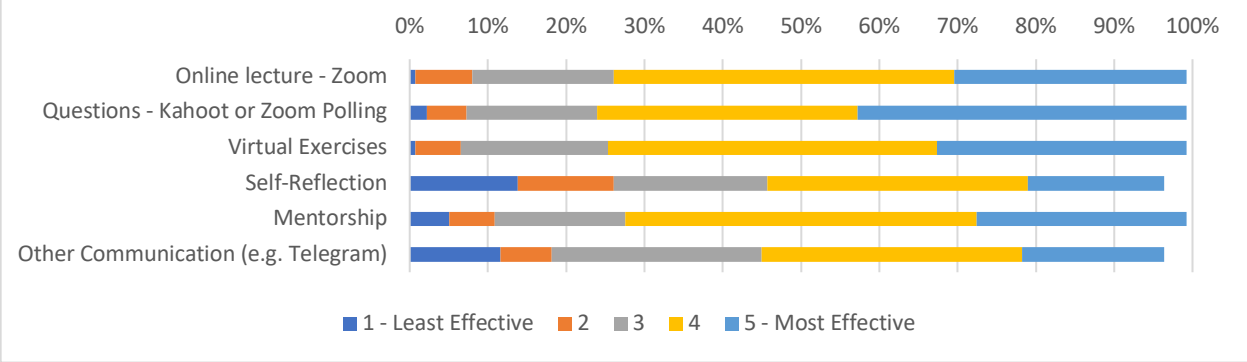

Figure 2. Effectiveness of Digital Learning Practices to learn course materials

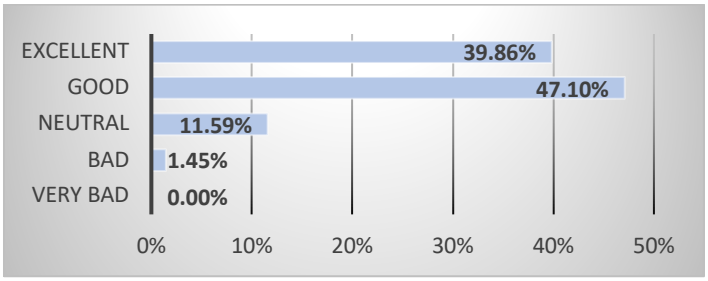

Figure 3. Overall Online Experience of the Course

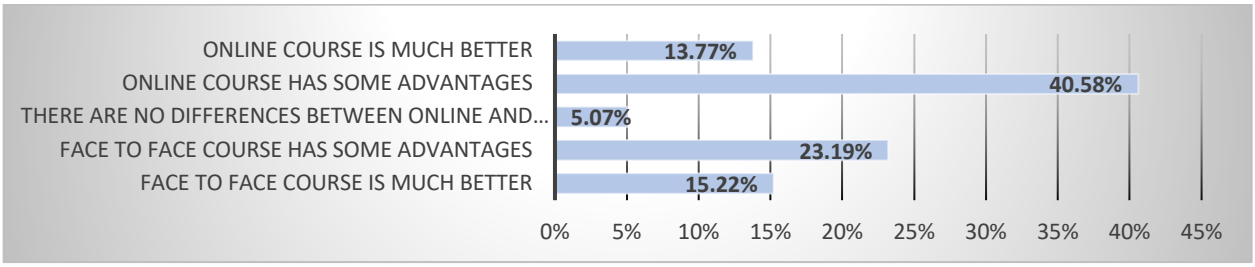

Figure 4. Comparison of Digital Learning with F2F Learning

With regard to RQ1 and our survey question 1 on the effectiveness of the digital learning practices to keep the student's interest in the course topics, students prefer Zoom Polling or Kahoot (3.99/5.0) followed by mentorship (3.91/5.0). Students can participate in answering questions or directly engage with the mentors. Some comments include:

- "The zoom polling/Kahoot forced me to pay attention because it's a call to action, and it helps me to point out which topics I'm personally lagging behind."
- "Zoom Polling or Kahoot challenges me intellectually"
- "Mentorship is effective as we can learn directly from the professor, instructor and/or teaching assistant"
- "mentorship means 1 to 1 time which is always effective"
- "Mentorship is easier online because all students need to do is to schedule an online meeting with prof for consultation anytime."

With regard to RQ2 and our survey question 2 on the effectiveness of the digital learning practices to learn the course topics, students prefer Zoom Polling or Kahoot (4.09/5.0). This is followed by the virtual exercises (3.99/5.0) and online lecture ZOOM (3.85/5.0). Despite not having F2F interaction, many students felt that learning from online lectures allows them to better learn the course topics compared to other practices. Some comments include:

- "Polling helps to do the revision. and online project helps to apply what we learned in class into real life."
- "The procedure of the online lecture conducted by the teaching team does not reduce the effectiveness in learning as I feel that materials being taught are still understandable as if I'm attending the lecture face-to-face"
- "Online lectures allow students to access to the recordings that they can refer to revise which physical lesson are not able to. Moreover, students need not travel here and there for lessons which allows them to have more time for revision or rest. This will increase student's productivity and focus."
- "I like how the zoom lecture is conducted and students can participate on the chat box as there is less interruption and more students can voice out and participate in the chat."
- "Online exercises/project: Learning by doing and practicing has been the most effective way for me to learn the topics."

For both survey question 1 and 2, Zoom Polling or Kahoot scores highest while self-reflection scores the lowest ratings. High correlation scores of 0.65 and 0.81 for Polling/Kahoot and self-reflection practices respectively indicate that learning practice to keep students' interest is positively correlated to them learning the course topics. Comparing the quantitative responses from survey question 1 and 2, we noted that mentorship and others are the only learning practices that rate better for keeping interest than learning

content. Mentorship rate 3.91 for interest and 3.83 for learning content. If we consider these ratings as comparable, it will seem to indicate that mentorship does keep student interest well with smaller group interaction, but they may not result in better learning of content.

With regard to RQ3 and our survey questions 3 and 4, a majority (87%) of the students felt that the digital learning experience is good or excellent. A majority (54%) of the students find digital learning much better or have some advantages. These two comments give a good summary of the student's perceptions of digital learning.

- "Online lesson has helped me in many ways such as more time for revision due to less travel time, recall what has been taught by watching lesson video again and again."
- "I feel that online course and face to face course have their own pros and cons. Online course is that people might not pay attention since they are at home and might not work well for others, however, it works well for me."

However, 38% of students still prefer F2F learning. Here are some qualitative feedbacks.

- "I feel that doing things online will always be a less effective experience compared to physical."
- "I felt that it was easy for us to disengage and do other things"

Threat to Validity

Our research is based on a subset of student feedback that may limit the generalization of the findings. The bias may result from unrepresentative sample data (i.e., data from students of two IS design courses for one semester from one university). However, we have a relatively large sample size of 138.

Summary of Lessons Learnt

1. Based on qualitative feedback, we noticed that at least 20 students mentioned that they are easily distracted, not pay attention or disengaged during digital learning. However, our quantitative data shows that student interest and content learning rate well by the students when they are presented with participatory learning practices. Most effective being questions using polling or Kahoot.
2. Digital learning reduces the level of personal engagement. In this case, the instructor and the teaching assistant's direct mentorships are now more valued by the students in our study. Due to the ease of setting up virtual meetings, such mentorships can also be easily arranged.
3. In terms of learning the course materials, digital learning through online lectures and virtual exercises using breakout rooms for discussions work well. Most students in this study are already familiar with using online technology such as Kahoot. These reduce the learning curve for our students. However, we need to ensure consistency in our delivery of the learning practices and management of online materials from varying technology used. Recorded lectures received some excellent comments for revision.
4. Students are receptive to digital learning and adapted quickly to the new model of digital learning. Many students felt less travel time and convenience to be the key factors.
5. Our observations show some challenges to digital learning. It is more challenging to track student's understanding by monitoring expressions and their overall progress online. We encourage them to switch on their video, but there will always be cases when students cannot do that, for example, inconvenience location or bandwidth issue. One workaround is to prompt questions and ask them to type in the chat box. The teaching assistant will then be able to identify any potential students who need further attention.
6. Another challenge is that group-based physical exercise practice can no longer be carried out. We used to conduct a group-based prototyping practice, the marshmallow challenge. For digital learning where the members are not close to each other, this exercise practice must be re-designed if it does not have an online substitute, such as the cloud-based architecture exercise.

Based on the lessons learnt, we recommend that educators include online learning practices that address distraction, engagement and self-directed learning. These can include participatory practices such as polling or Kahoot; engagement practices such as virtual mentoring sessions; and self-directed practices such as virtual breakout rooms for group discussions and online materials such as recorded lectures for individual pace learning. As we emerged from the Covid-19, we recommend that we continue these digital learning practices in a blended learning classroom.

Conclusion

Many educational institutions have adopted digital learning in various formats over the years. Due to the COVID-19 pandemic situation, these institutions now find it necessary to conduct digital learning for all of their courses over an entire semester. Learning practices that are conducted in traditional F2F lessons have to be adapted for digital learning. This paper evaluates a set of digital learning practices during this period. These digital learning practices span from online lectures, Kahoot or ZOOM Polling, virtual exercises, self-reflection and mentorship. Our research focuses on the effectiveness of these learning practices to keep student interest and learn course content. Our results show that participatory practice, Kahoot or polling works best for both. Mentorship engages students to keep their interest in the course topics. On the other hand, many students felt that our Zoom online lecture and virtual exercises help them learn course content. Recorded online lectures and virtual exercises conducted using virtual breakout rooms are self-directed practices for self-paced learning. The students' responses to digital learning experiences are generally good to excellent. 87% of our students can learn effectively from our online courses. 54% of students are finding that digital learning has advantages as compared to F2F learning. However, 38% still prefers F2F learning.

Our descriptive research collected empirical data for statistical analysis of effective digital learning practices for our population sample. Future studies with similar digital learning practices can validate our findings for a more generalized population. For example, our university IT infrastructure and country internet broadband speed are relatively high which may reduce some issues faced for online and blended learning. We hope this study gives an excellent example of the promising advantages of digital learning with the right set of learning practices. The digital learning practices can be adapted to a post-Covid blended learning approach to continue reaping the benefits of flexibility, interactivity and self-pacing. However, it is important to acknowledge that further research is necessary to look into teacher professional development (TPD) strategies that targets online and blended learning (OBL) during time of crisis.

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