IMPLEMENTATION OF E-PRACTICAL LESSONS DURING PANDEMIC

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ABSTRACT

The education sector was not sparred from the impact of Covid-19 and was forcefully made to adapt to the rapid changes arising from virus situations in various countries as necessary measures were implemented to prevent the virus surge and protect life. In the mist of the pandemic, learning should not be stopped even though lock-down and restrictive measures were placed. In the context of engineering education, lab practical sessions are paramount to the learning of the students where practical hands-on provide the students with the necessary experiences to complement their theoretical studies. With several schools been closed and switching to remote online education, the impact of lab practical studies was major as students were no longer able to return to school to use their equipment for learning and to perform their lab experiment. Through the exploitation of technologies, School of EEE (Singapore Polytechnic) addressed the challenges of e-practical disruptions which Singapore students faced during the “Circuit Breaker'' (CB) period in an innovative approach. During the CB, e-practical videos were produced for modules where learning were directly affected due to closure of labs as students were not allow to return to school to carry out day-to-day learning. The lab videos were designed to be short to enable micro-learning, allowing the students to better focus on the bite-sized content while enabling one to study individually at home through a flipped approach. Attributing to the joint effort and hard work from both teaching and technical staff in the video creation and editing process, the school was able to deploy e-practical videos to students weekly since the start of the “Circuit Breaker”. Till to date, more than 450 labs videos were created and deployed across different modules. With SP transition into “safe re-opening'' as virus situation in Singapore gets better, the lab videos were further improved and now jointly utilised as part of the students’ learning complementing other module materials. During the CB, a survey was carried out for more than 300 students who utilised the lab videos and results showed that more than 80% of the students found the lab videos to be useful in their learning and aided them in understanding the topic better while they carried out their full HBL.

KEYWORDS

Flipped learning, Micro-learning, E-practical videos, Standards: 8, 9, 10

INTRODUCTION

The management of disruption due to physical learning environment constraint in the 21st century is now more flexible due to technology advancement and wide adoption of the Internet across the Globe. Unlike the early days where lesson can only be conducted and confined within a physical environment, there are now online platforms and tools available for educators to explore, utilise and customizing them to best suit to the learning of the targeted students.

This enable one to be able to do remote studying easily, accessing their learning content anytime and anywhere through the Internet.

Covid-19 is an unprecedented event of this decade that causes major shocks and disruptions to almost all walks of life around the world. It changes the norm of how countries, businesses and individuals carry out their daily routines and interactions with one another. Prior to this worldwide pandemic (WHO, 2020), the industry landscape around the world was already facing pressure from abrupt disruptions due to waves of emerging technologies (Gartner, 2019) and digitalisation of industry, business and education (Agnes, 2012), (Martin & Ertzberger, 2013). Covid-19 rapidly hastened the original timeline for the world's preparation and pushed all into the acceptance of digitalisation for continuity and survivability of businesses. The education sector was not spared from the impact of this virus. In order to "Flatten the curve" and to slow down the speed of virus transmissions, several countries around the world adopted "lock downs" and restrictive orders to limit the flow of human traffic. During this period, many schools around the world were closed or made to carry out their lessons online to prevent mass gatherings of students. In the context of Singapore, we entered the "Circuit Breaker" period on 7 April 2020 (MOM, 2020). All schools and institutes of higher learning were mandated to shift to full HBL. Private educational institutions were similarly directed to do full home-based learning (HBL), or temporarily suspend classes.

As educators in a public Engineering school (School of Electrical & Electronic Engineering, Singapore Polytechnic), we have the duty to uphold the standard of learning and have a critical role to play in ensuring the continuity of students' learning regardless of changes in environment. Practical lab sessions are crucial in training future technicians and engineers. They equip students with the basic competencies to carry out the "hands-on" tasks required of a technical professional. For an engineering school, learning is predominantly carried out in a lab environment. This is where students learn about basic engineering skills, usage of equipment and developing skills in troubleshooting and using measuring tools. It is therefore essential that address the challenge for full home based learning during restriction and come up with alternative solutions to overcome the limits of students being removed from their physical learning environments. In this paper, the School of EEE's collective approach towards the generation of e-practical videos and their implementation during the "Circuit Breaker" to address the needs of the students will be presented. The generated online content was kept short and focused to achieve micro-learning through "Bite-sized" and delivered through a flipped approach. In order to validate the usefulness of the practical videos towards their learning, the analysis from more than 300 students is included in this manuscript. The survey presents a good overview in understanding the students' perceptions on the usefulness of the videos and areas for future improvements.

The rest of the paper is organized as follows: It begins with a discussion on the collective approach to implementing the e-practical videos. Following that, the paper focuses on the use of a micro-learning approach and discusses the categorization of e-practical videos and staff competency needed to support such an approach. The students' survey results and findings are presented in the next section, followed by the comments and feedback from the technical executives (TE) who contributed greatly in allowing this work to happen. Next, the reflection and future works for the development of the e-practical video was presented. Lastly, the conclusion of the manuscript was provided in the last section.

APPROACH TAKEN BY EEE TO ADDRESS LAB REQUIREMENTS

Lab practical sessions are paramount to the students' learning in an engineering school. Quoted from Henry Petroski (Professor of Civil Engineering at Duke University and recognized expert in failure analysis) *"Science is about knowing, engineering is about doing."* and Steve Jobs "*Design is not just what it looks like and feels like. Design is how it works*." From an engineering perspective, these quotes highlighted the importance of not relying on just textbook learning. A good future engineer needs to be able to apply, create, troubleshoot and ultimately make things work. Due to the limitations imposed on mass gatherings and movement countrywide during the CB, students were not allowed to return to their laboratories for learning. The School of EEE explored alternative solutions, taking full advantage of our built up competencies in student online learning (Wan, 2019), (Chew et. al, 2019), CDIO implementation (Chong et. al, 2010), self-directed learning (Toh et. al, 2020) and lab competencies of staff, developed within the school over the years. These were put to good use during this challenging period, enabling the school to minimize the learning disruptions faced by students. E-practical videos suited for micro-learning were created, edited and sent out to students. This provided a distinct advantage to students as the content was customized according to the needs of individual module across the different levels and diplomas. In addition, the videos could be integrated with other flipped learning content such as tutorial quizzes and lectures to provide an active learning and holistic experience for the students while they performed self-directed learning at home.

IMPLEMENTATION OF E-PRACTICAL IN EEE, A COLLECTIVE APPROACH

During the "Circuit Breaker" period, there were physical restrictions set in place to limit the number of essential staff returning to the school each day to carry out the implementation of HBL. Teamwork was especially vital during this critical time and the school came together as a cohesive unit to support each other. The technical executives (TEs) from TSA and academic staff (Specialists) worked closely together to construct the video content suited for the module topics. The TEs from the School of EEE also provided additional support by editing and disseminating the videos. Our staff members demonstrated strong teamwork and assisted others who were not able to return to the school.

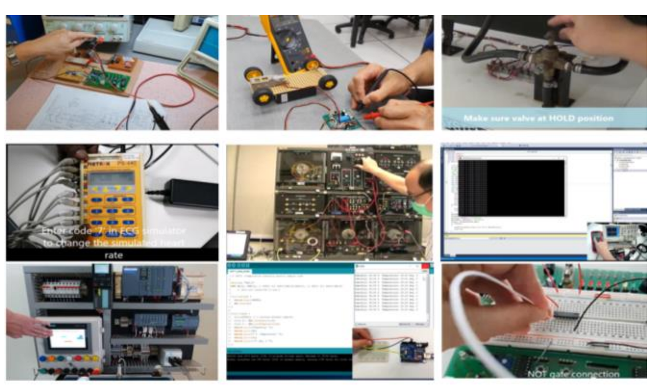


Figure 1. Screenshots from e-practical videos of different modules

The e-practical videos shown in figure 1 aims to familiarize the students with the individual experiment. They include recorded procedures for lab setup, steps on utilisation of the individual equipment and carrying out the experiment process. In a restricted environment where the student does not have access to the physical equipment, the e-practical videos provided them with a viable alternative to learn about the practical aspects of their module. In the next section, this paper looks into the characteristics of the e-practical video and how the concept of micro-learning was adapted to improve the learning of students.

MICRO-LEARNING AND CATEGORISATION OF VIDEO

Online Learning has been picking up speed and popularity in the last decade due to the easily available learning platforms through MOOC (Massive Open Online Courses) (Hayes, 2016) such as Coursera and edX. However, although most MOOC providers have reported large numbers of registered users for their courses on their respective platforms, the actual number of learners completing the courses was disappointing. Statistics (Forbes, 2019) from edX by MIT show the actual completion rate fell from 6% in 2014/15 to 3.13% in 2017/18. In the adaption of full online learning for all our students in the context of Singapore Polytechnic, we have to ask ourselves these tough questions. Are the students truly gaining real knowledge from the online lessons? Are the students just merely making their presence felt online without learning? How can we uphold our academic rigour and adjust our online leaning content to ensure that the students will be able to achieve good learning outcomes during the “Circuit Breaker”? Micro-learning (Hug, 2015), (Lindner, 2017) could be one of the small steps we take as we grapple with these questions.

“Micro-learning deals with relatively smaller learning units and short term-focused activities” (Hug, 2015). It is commonly associated with the domain of e-learning (Bruck, Motiwalla, & Foerster, 2012). During the “Circuit Breaker” period in Singapore, all public higher learning institutions were mandated to shift to full HBL We adapted the use of Micro-learning to target two key aspects in both the content development of the online material and the learning behaviour of a student. For content development, the e-practical videos were intentionally created to be “bite” sized to enable individual learners to focus on a specific learning outcome. In the School of EEE, we categorized our e-practical videos into three different levels. They were based on the depth of learning in comparison to the physical hands-on lesson and we align them in comparisons to relevant categories of the Bloom’s Taxonomy.

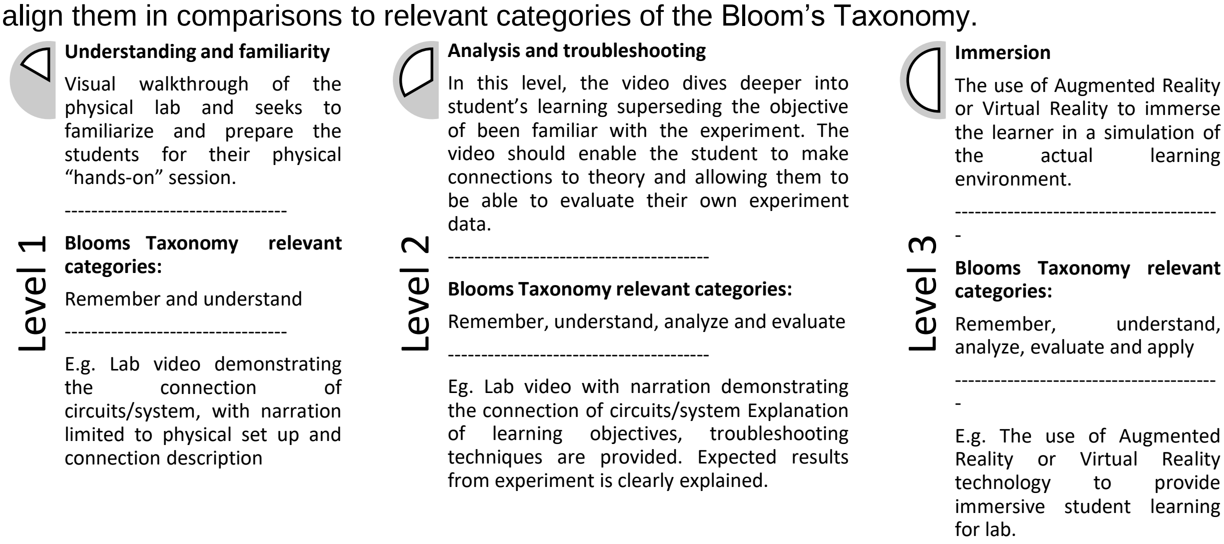


Figure 2. Categorization of E-practical videos

The e-practical videos were created with the intention for students to be able to gain familiarities and insights to best achieve the learning objectives for individual lab. Figure 2 provided the categorization of the different depths of learning a student can experience when using the online learning content. During the CB period, the videos deployed for students’ usage were at least of level 1 quality. The categorization of the e-practical video is provided next. For level 1, the content aims to provide a visual walkthrough of the physical lab activities to familiarize and prepare the students for their physical “hands-on” session when they eventually return to school. Level 2 practical videos deal with a higher order of learning based on Bloom's Taxonomy that supersedes the objective of getting the student to only be familiar with the experiment. In this level, the video ventures deeper into their learning, enabling them to make connections to theory and allowing them to be able to analyse and evaluate their experiment data. Level 3 aims to emulate the experience in physical labs through 'virtual" hands-on sessions, giving the students a sense of immersion.

Moving beyond the CB period, more e-practical videos are created and added to the video repository. Looking back before the pandemic where only a handful of e-practical videos were created and scope which were limited to individual module, till to date where more than 450 video content were deployed for student's utilisation widespread across modules as they progressively return back to the classroom with improving Covid-19 situation in Singapore. The created e-practical videos are now used in conjunction with their physical lab lesson to supplement their learning and also served as a learning content for their pre-lesson studies before coming into the physical lab. The school will progressively increase the levels of the created videos as we seek to explore the use of AR/VR (level 3) or other simulation tools to provide realistic "hands-on" experiences thus further enhancing the learning experiences of students while carrying out the experiment at home or through a remote site.

SYNERGY OF TE COMPETENCY TO E-PRACTICAL VIDEOS CREATION

In order for technical executives to be able to create the e-practical videos together with the module specialists, they require good foundational knowledge in their respective lab modules and individual experiments. By knowing their lab content well, the critical information from the experiment can be preserved throughout the process of recording, editing and presenting to the students for their learning. The School of EEE established the module competency framework (recently revised in 2019) as a systematic way to define the competency levels of individual TEs for different modules under their care. The definitions for the different levels are shown in Figure 3.

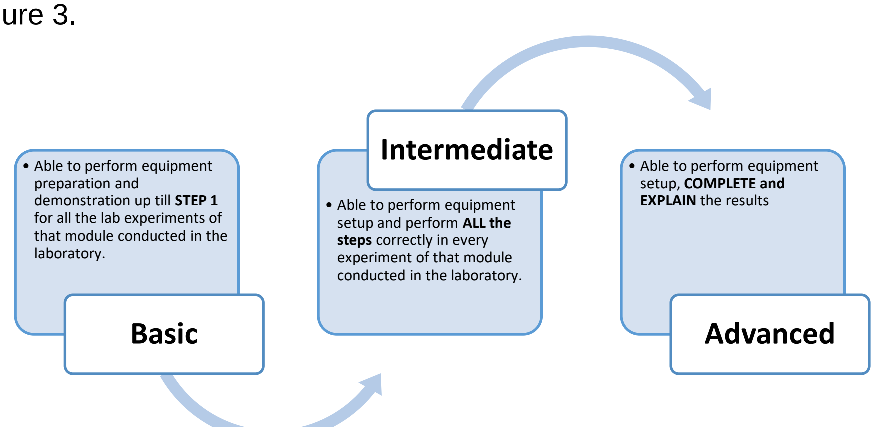


Figure 3. Competency levels for TE in support of modules in the School of EEE

A total of 41 TEs in the School of EEE achieved 100% "Basic" competency for at least one module. 98% achieved intermediate and 40% have progressed to the "Advanced" level. The creation of the e-practical videos was thus undertaken by the TEs based on their competency levels according to the established framework.

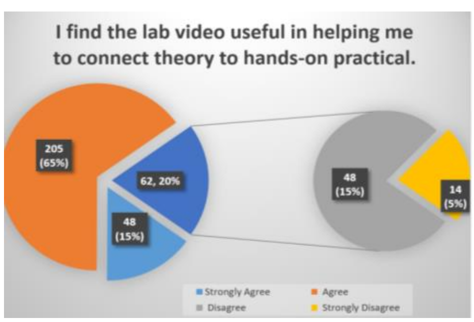
DEPLOYMENT OF E-PRACTICAL VIDEOS DURING COVID-19

During the CB, most of the module practical sessions were affected as students were mandated to perform full home-based learning. The lab videos were deployed weekly to the students in order to minimize the impact to their learning. An advantage of the e-practical videos is in their flexibility of utilisation, as they can be used even after CB. During the catch-up week for labs, students make use of the videos to refresh their memories before returning to school for the actual physical experiments.

The successful deployment of the e-practical videos opens up many opportunities for both manpower and resource optimization for the school. As students gradually returned to school during Post-CB, lab practical session were redesigned to be compressed (2 lab sessions combined into a single one) to maximize the students' learning while adhering to the safe distancing measures. The lab videos enable optimization of student learning, enabling them to familiarize themselves with the procedural steps of practical lab. With the improvement in quality of the lab videos and with more lab videos being utilized for self-learning, lab time previously used for procedural explanation can now be free up for actual practice by both full and part-time students to better build their technical know-how.

STUDENT SURVEY RESULTS

The main objective of the e-practical video is to minimise the disruption in student learning towards practical lab session during the pandemic. It is important for us to be able to know if the videos are useful for them and what are the areas for improvement to better aid their understanding while they are learning from home. For data collection, we have conducted two surveys looking into (1) Effectiveness of using the e-practical videos for students' learning and (2) Mind-set of the TSA staff contributing to the creation of the lab videos. For the student survey, 317 students from year one to three participated. Each question in the survey was measured using the 4-point Likert Scale format (Strongly Disagree, Disagree, Agree and Strongly Agree) with open-ended questions at the end.



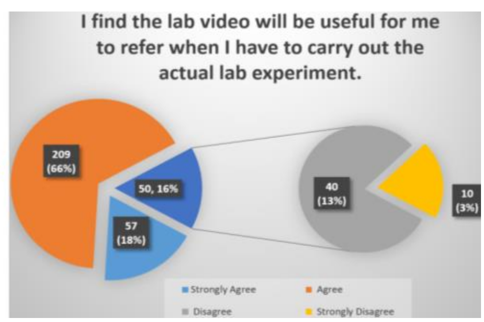


Figure 4a. Connect theory to hands-on practical Figure 4b. Familiarity to actual lab experiment

Figures 4a and 4b focused on the usefulness of the e-practical videos during their dissemination to the different years of students in the School of EEE. Figure 4a shows that out of the 315 students who answered the question, 80% (253 students - Strongly agree and Agree) found the videos to be useful in helping them apply the theoretical knowledge they gained from lectures and tutorial. The connection between theoretical learning and practical is an important aspect of learning especially in an engineering context where theoretical knowledge gained will not be sufficient if the students want to find solutions to solve real-world problems. Figure 4b surveyed the students' feedback on the usefulness of videos as a reference when doing the actual lab. The data showed that out of the 316 students who answered this question, 84% (266 students - Strongly agree and Agree) responded positively. This aligns with our original objective of the e-practical videos to improve the familiarity of the students in practical aspects and allow them to improve their learning experience.

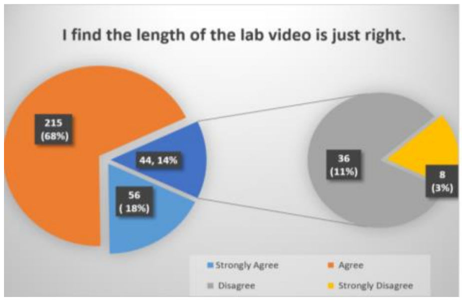


Figure 5a. Aspect of Micro-learning

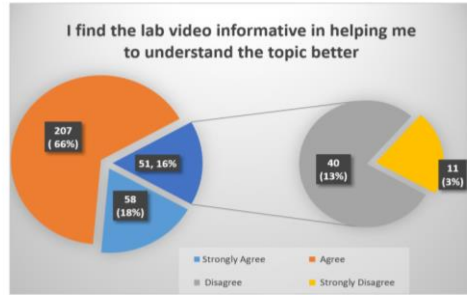


Figure 5b. Understanding of topic

Figures 5a and 5b focused on the characteristic of the e-practical videos and whether the presentation of information is useful in helping the students understand the topic better. Figure 5a shows that out of 315 responses, 86% (271 students - Strongly agree and Agree) thought that the length of the videos were just right. During the creation of the e-practical videos, the length of the videos were kept intentionally short to enable “bite sized” learning. The students will now have the flexibility to hone in on the areas they need help with, and to watch and review that specific topic again anytime they wish. Figure 5b demonstrated this fact and shows that out of the 316 students who responded to the question, 84% (265 students - Strongly agree and Agree) felt that the videos are informative and helped them to understand the topic better. However, Figure 5b does reveal that 16% (51 students - Strongly disagree and disagree) felt there could be improvements. This could be addressed in the future as more Level 2 and 3 videos are created. Through virtual “hands-on” and improvement in the details of the videos, better knowledge transfer and learning efficiency could be achieved.
In the next section, feedback of students were consolidated and presented. The open-ended questions enabled us to gain better insights into the students’ learning behaviour and usefulness of the e-practical videos.

Findings from responses collected from three open-ended questions

Question 1: What do you like about the lab videos?
Question 2: What do you dislike about the lab videos?
Question 3: What could have been done better for any one of these three - Lab video, online learning material and online assessment - to help you in your learning during full HBL?

For open-ended question 1, the students generally agree that the e-practical videos are informative and enabled them to visualise and prepare for the physical lab when they return to school. The repetitive nature of the e-practical videos is useful for some students as they were able to review parts of the e-practical concepts they were not familiar with at their own time and pace. Some of the comments from students were as follows:

“I liked how the tutor demonstrated the lab experiments so that we know how to carry out the experiments ourselves. Also, I can rewind the videos if I need to clarify something without asking the teacher to repeat themselves.”

DCPE year 1, Anonymous

“They help to guide us through lessons even though we are not in campus.”

DEEE year 1, Anonymous

"It is very step-by-step in the procedures. Hence it is okay for students to follow through".

DEB year 2, Anonymous

"They can serve as a good reference when I have problems carrying out the actual experiments".

DEEE year 3, Anonymous

For open-ended question 2, the students shared honest reflections on what they disliked about the videos. Some of the comments from students are as follows:

"I am not able to interact with the teacher so if I do not understand, I only can refer back to the videos and notes"

DEEE Year 1, Anonymous

"Despite being step-by-step, I feel that it is really not the same as us doing the experiment itself and I feel that I would need to actually do the experiment to be able to understand and remember the materials better."

DEB Year 2, Anonymous

For open-ended question 3, the students shared their opinions on what they think could be improved (in the context of lab videos). Some of the comments from students are as follows:

"lab videos should be more interesting and interactive……."

DCPE year 1, Anonymous

"Carry out lab experiments videos like actual lessons, like a pov of a student listening and doing the lab experiment"

DEEE Year 1, Anonymous

The survey done by more than 300 students across all diplomas and levels provides good insights into the usefulness of the e-practical videos, characteristics of the e-practical videos and what can be improved in the future. From the results, it shows that the videos are useful for the students while studying at home online. The short videos enable the students to enhance their learning and allow them to review the content anytime and anywhere. For future lessons, interactivity of the videos will be improved to eventually allow it to mimic the actual practical session.

TSA STAFF SURVEY

In this work, the technical executives from TSA division played a critical role in the lab video production. In the absence of their commitment and willingness to go the extra mile during this challenging time, the students' learning would have been affected. This section of the manuscript centres on them and understanding their mind-set during Covid-19 period.

This survey captured the feedback from all 41 technical executives in TSA division.

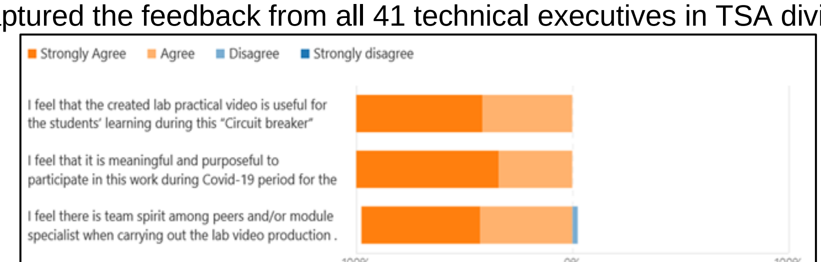


Figure 6. Mind-set and teamwork

The survey from Figure 6 shows a strong sense of commitment among the TSA staff and all of them feel they are making a difference in influencing the students' learning. 100% of the staff agree (56% Strongly agree and 44% Agree) that they think the e-practical videos created are useful for the students' individual learning. All of them (63% Strongly agree and 37% Agree) also felt it was meaningful and purposeful even during the challenging period to return to school to fulfil this part of the work. From the survey, there is a strong sense of team spirit (95% Strongly agree and agree) within the TSA group and specialists. This is the key reason why the school was able to tackle the challenge of Covid-19 head-on and maintain academic rigour for our students.

In the following section, feedback from the TSA staff were consolidated and presented. The open-ended questions allowed us to gain better insights into the TSA staff motivation in the lab video production.

Findings from responses collected from open-ended questions

Question: What motivates you to return to campus to carry out the lab video production?

"Knowing the importance and purpose of creating the lab video is to let students who are unable to come to campus a head start or giving them a general idea of the experiments"

Don, Ng Kheng Ann (TSA)

"Felt this was the next best option for students to reinforce their knowledge and have a better understanding of the subject, without having physical access to the lab equipment."

Chu Tee Khiang (TSA)

"As a parent, I would like my children (students) to learn as much as they can. This is my motivation.'

How Seo Tin (TSA)

"For Covid19 pandemic to allow student walk through the lab."

Tan Chin Hee (TSA)

"For the benefit of the students"

Malek (TSA)

"It is my duty to do it. At least students have alternative ways of learning during Circuit Breaker period."

Chong Wee Tat (TSA)

RELECTION AND FUTURE WORKS

The widespread cases of Covid-19 around the world results in several challenges and disruptions to everyone normal livelihood. For an education institute, the ways we commonly reach out to our students and how they can learn through hands-on experiments are now impacted due to Covid-19. During this difficult time, there is always a choice in not doing anything and waiting for the pandemic to pass. However, there is no certainty how long the virus will last. The longer it takes for the society to return back to normalcy and for students to return back to school, the greater will be the learning gap of our students if no mitigation measures were carried out.

Reflecting back to the period where the School of EEE is closed during CB, we are heartened by the positive mind-set demonstrated by our staff (as shown from survey in Figure 6) and the willingness shown in going the extra mile to carry out measures required to reduce the disruptions towards our students' learning. The created e-practical videos were also deemed useful by student (Figure 4 and 5) which supported their learning during this difficult time.

Looking ahead, the created e-practical videos bring many benefits for the students in the School of EEE and are not limited to only the Covid-19 period. The students can use them for self-directed learning during normal school time and they can go at their own pace as they improve their knowledge of the different practical sessions across modules.

For future works, the school will build on this strength to improve the e-practical videos to achieve level 2 and level 3 interactions. The e-practical videos open up many exciting opportunities for the school. This includes enabling the School of EEE to explore full HBL across the semester to utilize the strength of e-practical videos complementing online asynchronous lectures, synchronous tutorials and assessments that we have developed during this time. The learning focus will then be on mastery in skills practice during the actual lab sessions as instructional procedural steps can be learned through the use of the lab videos beforehand. When there is a need to catch up with the practical, the lab sessions can be redesigned to be carried out in a shorter time by combining what were previously two weeks of lab sessions into a single one to optimize the time that students spent in the lab for their learning.

CONCLUSIONS

This paper presented the collective approach from School of EEE, Singapore Polytechnic in addressing the challenges posed by the restriction due to Covid-19 for full home-based learning. Practical lab lesson is an important aspect for an engineering school for students to gain equipment knowledge and hands-on experiences. In order to lessen the impact on students' learning and to continue upholding the academic rigour required of an engineering school, much effort was devoted for the dissemination of the e-practical videos to the students during the "Circuit Breaker" period. The lab videos encourage students to cultivate self-directed learning giving them the flexibility to learn at their own pace.

Results from survey shows that the lab practical video were useful for the students in connecting theoretical knowledge to practical "know how" during the Covid-19 CB period. Moving ahead, the successful deployment of e-practical videos leads to more opportunities for both manpower and resource optimization for the school as we look beyond Covid-19.

ACKNOWLEDGEMENTS

This manuscript is dedicated to all the Technical Executives (TSA) and the Specialists (TD) in the School of EEE, Singapore Polytechnic and the authors wish to highlight their contributions. The school is highly appreciative of their hard work and sacrifices made during the "Circuit Breaker" period. It is through their collective effort during this challenging time that the impact to the students' learning was greatly minimized, and this piece of work for the students was made possible.

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BIOGRAPHICAL INFORMATION

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Boon-Chor Seow received his B.Eng. degree and Master of Science in electrical engineering from National University of Singapore, in 1984 and 1998 respectively. He have in-depth experiences in the domain of PCB and product testing. He joined National Semiconductor Pte Ltd in 1984 as a product test engineer and was a PCB and System test engineer with Unisys International Pte Ltd in 1987. In 1991, he joined Hewlett Packard Pte Ltd as PCB test engineer. He joined Singapore Polytechnic as a lecturer under School of Electrical and Electronic Engineering in 1992. He is currently a manager and in charge of school events organisation such as technical conferences and project exhibition to showcase staff and students' capability and to enhance students' learning experiences in the School.

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Ser-Khoon Toh is currently the Director, School of Electrical & Electronic Engineering, Singapore Polytechnic. Under his leadership, the School continues to be a strong advocator and practitioner for CDIO, Design Thinking and FabLab-based curriculum for the Engineering diploma programmes. His current focus is on nurturing and preparing learners to be self-directed and work-life and world-ready. In the area of teaching innovation, the emphasis will be on the use of educational technology and the application of learning analytics for engineering education.

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