ADAPTING CDIO FRAMEWORK TO CULTIVATE SELF-DIRECTED LEARNING DURING COVID-19 PANDEMIC

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ABSTRACT

One of the goals of the School of EEE is to cultivate self-directed learning (SDL) mind-set in all its graduates with its holistic SDL eco-system, whatever the situation. The coronavirus pandemic required changes to its implementation of curriculum delivery. Campus closure in April to June 2020 forced the switch to full Home-based Learning (HBL) in the form of online asynchronous lectures, synchronous online tutorials, e-practical lessons, and e-proctoring assessments to enable students' learning to continue. This paper discusses how the cultivation of SDL continued to be the main focus of the School through the effective deployment of HBL and guided by the various CDIO Standards despite the ravages brought about by the pandemic. This resulted in the transformation from the traditional learner-centric classroom delivery to learner-centric HBL, minimising the impact on learning outcomes (Standard 2) and yet cultivating the SDL mind-set for 2400 full-time and 650 part-time students. Previously developed learning contents for face-to-face delivery were converted to asynchronous form, with close follow-up by the teaching staff of their students during the synchronous online tutorial lessons for active learning (Standard 8). The School also capitalised on the free trial of add-in for PowerPoint, enabling increase student interactivity through their inputs and feedback on a single platform during synchronous online tutorial lessons. The use of learning analytics to provide teaching staff with real-time visual feedback on the students' learning ability was also carried out. Lab practical videos, together with the deployment of appropriate simulation software where available, were used so that students could learn the practical experiments/projects although the lab venues were not accessible (Standard 6). Regular learning assessments (Standard 11) were conducted online with e-proctoring to ensure students were progressing and coping well despite campus closure. Training of teaching staff to enable them to conduct online synchronous lessons effectively (Standard 10) was conducted as the majority had previous little experience in online teaching. Various survey results are shared in this paper, and these affirm that student learning can continue in the new norm of engineering teaching and learning, with on-going improvements. The changes necessitated by the curriculum transformation needed to ensure that student learning continues in the face of restrictions brought about by the coronavirus pandemic, though overwhelmingly challenging at times, are catalytic to help shape our students to become self-directed learners. It drives home the point, that this need for SDL is even more urgent in the new norm of teaching and learning.

KEYWORDS

Self-Directed Learning, Learning Analytics, Whole-school, Standards: 2,6,8,10,11

INTRODUCTION

A newly identified coronavirus, SARS-CoV-2, has caused a worldwide pandemic of respiratory illness, called COVID-19. It is highly infectious with many healthcare systems around the world struggling to cope. This had led to drastic steps of lockdown imposed in many countries,

affecting schools and educational institutions as the in-campus face-to-face lessons could no longer be conducted.

Prior to the coronavirus pandemic, the School of Electrical & Electronic Engineering (SEEE) already has in place an enhanced engineering education model that aims to produce graduates who are independent and self-directed in their mindset with a distinctive metacognitive skillset. This involves a comprehensive whole school approach that starts on the day when a student joins the school right up to the final year examinations.

The school firmly believes that having a self-directed learning mind-set is indispensable for one to be work-ready, life-ready, and world-ready in order to succeed in the 21st century. With this belief, elements of self-directedness are infused in all activities that a student is exposed to throughout the three-year course of study, either through formal or informal means, structured or non-structured ways, and within or outside of the school environment.

To assess how well the curriculum has succeeded in moulding the students to be self-directed, three SDL surveys were conducted on the first batch of students starting in April 2019. The results, discussed later in this paper, affirmed the measures taken by the school in the infusion of self-directedness were on the right track. (Toh, Chia, Tan, & Safura, 2020).

SCHOOL-WIDE RESPONSE TO COVID-19 PANDEMIC

With the onslaught of the coronavirus spreading ferociously across the world in early February 2020, the polytechnic started to implement contingency plans to prepare for the day when the virus reached Singapore's shores. Preparations were implemented for the worst-case scenario where a complete lock-down had to be imposed in the country to contain the spread of the virus and HBL had to be implemented. The convened School's task force had identified the following areas to focus on in order to educate and train the students to acquire a SDL mind-set and a metacognitive skillset without compromising on the academic rigour, quality of assessment and student engagement:-

- Asynchronous lectures and synchronous online tutorials (Standard 8)
- E-practical lessons (Standard 6)
- E-proctoring assessments (Standard 11)
- Using real-time feedback for formative assessments (Standard 8)

The asynchronous lectures and e-practical lessons required the students to self-learn and this would lead to strengthening their SDL mind-set while the synchronous online tutorial lessons helped the students by hand-holding them to understand difficult concepts. The real-time feedback allowed the teaching staff to pinpoint the areas that students were weak in so that help could be rendered in the appropriate areas during the synchronous online tutorials as a form of safety-net. The e-proctoring assessments served to validate the overall quality of students' learning.

When the worst-case scenario of campus closure became a reality on 7 April 2020, the earlier decision to transform all learning contents into HBL proved to be fortunate on hindsight. On 18 June 2020, Phase 2 replaced the lockdown with safe management measures that included mandatory wearing of face mask in public, safe-distancing measures at all times and in all places, and with a maximum of five persons allowed to gather at any one time. This meant that students could return to campus but in controlled numbers. For laboratories, they were rostered for half class size of 10 to 11 students each time, instead of the full class size of up to 22

students. However, all lectures and tutorial lessons continued in the same online manner as during the lockdown.

ASYNCHRONOUS LECTURES AND SYNCHRONOUS ONLINE TUTORIALS

In the first semester of the academic year (AY) 2020/2021 starting in April 2020, there were altogether 130 modules offered across all five diploma courses school-wide. Out of this total, six were available online with fully developed asynchronous learning contents. Students taking these modules understood that they were expected to learn through blended flipped learning. The other 124 modules were supposed to be taught face-to-face in the campus based on three components – namely lecture, tutorial and practical. However, this was no longer possible due to the lockdown and hence all the modules were converted to blended flipped learning. It was thus a golden opportunity provided by the pandemic to accelerate the conversion of these 124 modules to blended flipped learning as any earlier reservation pre-pandemic, over their implementation fizzled out.

Asynchronous Lectures

The School had adopted the CDIO Standards as the guiding principles in the development of its curriculum. With the conversion to HBL, the Standards were again heavily referenced to ensure the students continue to be engaged directly in thinking and problem-solving activities (Standard 8) albeit in a virtual setting. To develop a fully flipped module on par with the six that were already available, the school understood that time was the essence. With the limited time available to achieve the same level of readiness as in a complete blended flipped learning module, the school had decided to adopt a framework to prepare staff based on the readiness of the online learning materials as given in Table 1.

Table 1. Definition for different levels of flipped learning materials

Category	Flipped Learning Materials	Objectives
Level 1	PowerPoint slides with voice over narration only/edited videos recorded during lessons in bite sizes	Self-learning by accessing online learning materials anytime, anywhere
Level 2	• Bite-sized PowerPoint slides with voice over narration only/edited videos recorded during lessons/Articulate Rise 360 with embedded voice & videos • Self-assessment quizzes at the end of each segment • Readiness check at the end of the topic	Available information based on the students' learning is used for data analytics to facilitate differentiated teaching where not only the weaker students are helped but the better ones are also stretched to realise their full potential
Level 3	• Animated graphics • Interactive branching scenarios • Interactive videos and audios	Designed to simplify the understanding and explanation of complex and abstract principles/ theories

The conversion to blended flipped learning started about a month before the lockdown was imposed and when the semester started, HBL learning materials were available for at least the first five lessons in all modules. Work on the conversion continued as the semester progressed and all modules were fully converted to Level 1 before the end of the semester in August 2020. The success of the implementation of the asynchronous lectures in Semester 1 gave the School a much-needed boost and raised its confidence to phase out face-to-face lectures and replacing these with asynchronous blended flipped learning. This would become the new normal going forward. Meanwhile, the teaching staff began work on the Level 1 modules with the aim to enhancing it to meet the requirements of Level 2.

Synchronous Online Tutorials

During the lockdown in Term 1 of Semester 1 (April-May 2020), lecturers were conducting full-blown online synchronous lessons for the very first time for all modules. As could be expected, many lecturers were uneasy and uncomfortable through lack of experience. Those who were averse to using technology faced even greater challenges. Nevertheless, many of the dedicated and committed lecturers compensated their lack of confidence in conducting virtual lessons by spending longer than the allocated time to conduct their online lessons. Initially, many were under tremendous stress but as the weeks went by, the lecturers slowly adapted to the new way of conducting lessons and this became more manageable for them. It also helped that most of the lecturers were prepared to engage their students outside of the allocated lesson hours to help their students learn.

The Teaching & Learning (T&L) Unit provided the necessary support by conducting workshops on how to conduct effective online lessons, focussing on students' interaction and engagement. The Unit also introduced two other measures to make conducting synchronous online lessons less daunting - the use of a newly available PowerPoint add-in called ClassPoint and the purchase of computer-writing pads with stylus pens. ClassPoint is a student response system (SRS) like Kahoot, Socrative and Mentimeter but its advantage lies in its seamless integration with PowerPoint, unlike other SRSs that were based on different platforms. The computer-writing pads with stylus pens made it possible for the lecturers to complement verbal explanation with written illustration during online lessons. However, the School is mindful that technology is only a tool, and that the student is at the heart of the teaching and learning initiatives ((Loh, Lim, & Sun, 2021).

E-PRACTICAL LESSONS

The School's curricula is fully supported by engineering workspaces for all components of hands-on, knowledge, and skills learning (Standard 6). With the lockdown, the hands-on component was temporary suspended. However, the School was optimistic that the lockdown was a short-term measure that would be lifted eventually. With this in mind, lab practical videos were developed for all the modules that required the use of laboratories in conducting practical lessons. The lab practical videos aimed to familiarize the students with the individual experiments. These included recorded procedures such as equipment and lab setup, how to use different equipment and carrying out the individual experiments. With campus closure, the lab practical videos provided students with a viable alternative to learn about the practical aspects of their modules. The durations of these videos were deliberately kept short as the objective was on micro-learning (Lindner, 2007), for better emphasis on the key content areas.

With Phase 2 implemented in June 2020, lab practical sessions that were missed during the earlier campus closure in Term 1 resumed for students but in controlled numbers. Having accessed and viewed the lab practical videos earlier, the students were able to complete each lab in less time than would have been needed previously as the usual time needed for the lab briefing at the start of each lab session have also been partly covered in the lab videos. In short, the usual two-hour duration for a typical lab session needed in the past could allow for two different experiments to be combined and conducted during the same time, thus minimising the impact for the students who missed out on the practical lessons during the earlier campus closure.

The School categorized lab practical videos into three different levels based on the depth of learning in comparison to the physical hands-on lesson with reference to Bloom's Taxonomy

as given in Figure 1. This is not to be confused with the levels accorded to the development of the asynchronous learning contents.

Although students were able to return to the laboratories to conduct the experiments, teaching staff continued to work on improving the lab videos from Level 1 to Level 2 so that these could be more informative and could become part of the future training to instill self-directed learning in the students.

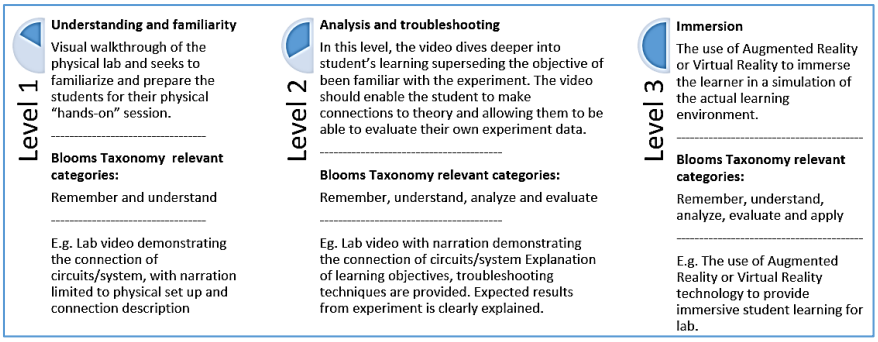

Figure 1. Categorization of E-Practical Videos

E-PROCTORING OF ONLINE ASSESSMENTS

The need for constructive alignment between learning outcomes and aligning of both teaching and learning activities and the assessment activities, is integral to ensuring the quality of a good course design and delivery. Assessments are thus inseparable from the teaching and learning activities as Standard 11 states that assessment of student learning is the measure of the extent to which each student achieves the intended specified learning outcomes. There was a plethora of alternative assessments (Gordon, 2020) suggested that could be considered. Although the School decided to continue with the usual assessments as most of those suggested could not meet the need for constructive alignment mentioned earlier for many of the engineering modules taught, these assessments had to be converted to online versions.

The two forms of alternative innovative assessments that were put in place were: COVID Formative Assessment (cFA) and COVID Mid-Semester Test (cMST), with the former being fully online small-stakes assessments conducted during Term 1, and the latter being the fully online version of the usual paper-based mid-semester test conducted at the end of Term 1. The cFA would apply to about 92% of all modules, or 130 modules, while the cMST applied to 73% of modules, or 102 modules, when implemented.

To ensure the academic integrity of the remote online assessments, many factors were considered for the implementation of the cFAs and the cMST. These included the elements such as "unstructured" short questions that test on analysis and application with answers not easily obtained using online search, no backtracking, one question shown at a time, randomness of question and randomness of answers, as in the case of multiple-choice questions, as recommended (Budhai, 2020) (Weleschuk, Dyjur, & Kelly, 2019) (Ragupathi, Jan 2020). Another key consideration was the use of online proctoring, an essential feature for assessments to minimise cheating, and as a preventive measure to prevent such incidents from taking place as these had happened in other IHLs (Dyer, Pettyjohn, & Saladin, 2020) (Sun, 2020).

There was a need also to get buy-in from the school's various stakeholders; staff, students and parents, and to initiate appropriate change management to bring it about. The process had to be made palatable for staff who were already saddled with HBL and had to be convinced of the need to have the new assessment process, albeit remotely, assessment being an integral part of student learning. Further, to ensure the smooth conduct of the process, relevant training by the school's Teaching and Learning team had to be conducted.

Mindful that students were undergoing e-proctoring for the first time, the school stepped up various measures to prepare them. That entailed coaching them on the new process, looking into whether they were equipped in terms of the computer devices and handphones, with home network access, and giving attention to those with special needs, who were uncomfortable or had difficulty with the demands of remote e-proctoring.

Parents had to have their fears allayed as they were concerned about the adverse impact that the new process might have on their child's performance. Given the very short lead time (two weeks) within which the school had to address those challenges, and above all, to come up with a solution that not only would do so, but was also affordable and had a quick turnaround, it was, indeed, a daunting task, to say the least.

USING REAL-TIME FEEDBACK IN FORMATIVE ASSESSMENT DURING HBL

The School also started a project based on a technology-driven framework to incorporate the application of EduTech tools and data visualization software to facilitate learning of students' performances. This is in line with Standard 11 that covers the assessment of student learning. The aim is to equip teaching faculty with both pedagogic and technical capabilities in using EduTech and the students' formative test data to derive learning insights. These insights are then used to implement subsequent learning interventions to enhance student learning (e.g. attainment, engagement).

The following broad methodology was used in the project intervention strategy:

1. Students do a readiness test on student response system (Socrative) before class contact time
2. Students take a 30-minute time-tabled schedule cFA as described in the earlier segment
3. Students complete a 1-minute short exit poll before end of synchronous online tutorial lesson on Microsoft TEAMS
4. Lecturers analyse the data further via Power BI Dashboard and plan for intervention actions during synchronous online lessons

The process is illustrated in Figure 2.

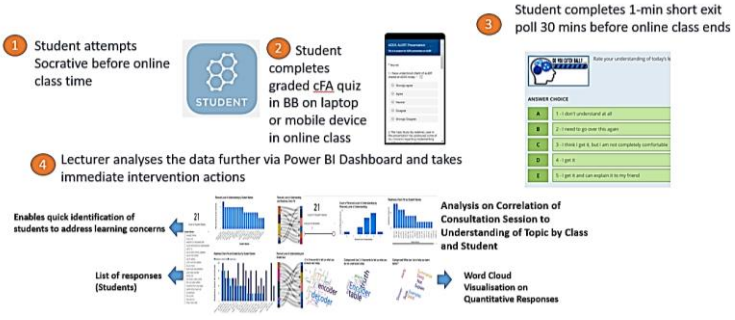

Figure 2. Real time student feedback process

SURVEYS OF STUDENT VIEWS ON THEIR LEARNING AND THE IMPACT ON SDL

Several surveys were administered to find out how the students were coping with the changes implemented. For the HBL surveys on the asynchronous and synchronous online lessons, these were conducted at the institutional level while the surveys on lab videos, online cFA and cMST assessments were conducted at the school level.

Surveys on HBL Asynchronous and Synchronous Online Lessons

Surveys were conducted at mid-semester (June 2020) and at the end-of-semester (August 2020). These required all School of EEE students to feedback on all modules that they had taken. This means that if a student were taking four different modules, he would have given four responses. For the whole School, the total responses received were 5847 and 7329 for the mid-semester and end-of-semester, respectively. Both surveys consisted of two common statements related to student learning and engagement, with a 6-point Likert scale and another question that sought feedback on areas of improvement.

E-learning/lecture materials for the asynchronous online lessons had been effective for student learning

The results in Table 2 and Figures 3a and 3B show more than 84% of the students felt that the e-Learning/lecture materials were effective for their learning.

Table 2. Results of surveys on effectiveness of asynchronous learning contents

	Mid-Semester	End-of-Semester
Average score out of a 6-point Likert scale	4.44	4.44
Percentage of students generally felt that the e-Learning/lecture materials were effective for their learning	86% (Total=5847)	84% (Total=7329)

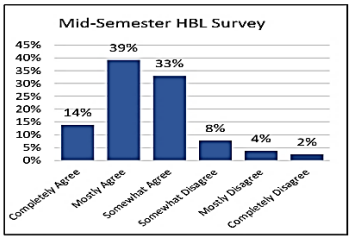

Figure 3a. Results of mid-semester survey

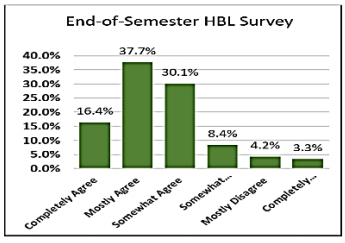

Figure 3b. Results of end-of-semester

Synchronous "live" online lessons had been effective for student learning

More than 81% of the students felt that the synchronous online lessons had been effective for their learning as shown by the results in Table 3 and Figures 4a and 4b.

Table 3. Results of surveys on effectiveness of synchronous online lessons

	Mid-Semester	End-of-Semester
Average score out of a 6-point Likert scale	4.37	4.32
Percentage of students generally felt that the synchronous "live" sessions are effective for their learning	84% (Total=5847)	81% (Total=7329)

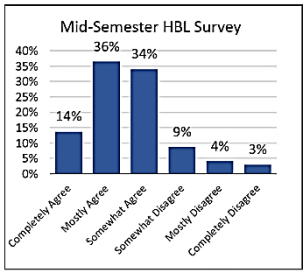

Figure 4a. Results of mid-semester survey

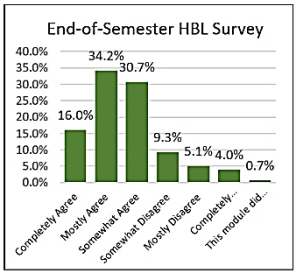

Figure 4b. Results of end-of-semester

Areas that have supported students well in modules during HBL

The top three areas that have supported the students well during HBL as shown in Figure 5 were:

- Sufficient learning contents (e.g. lecture notes)
- Easy to access and navigate e-learning/lecture materials
- Clear and easy to understand online learning materials

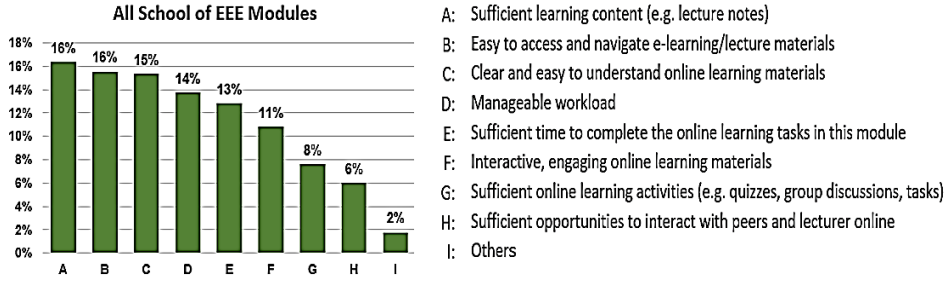

Figure 5. Areas that contributed towards students' HBL learning

Survey on E-Practical Lessons

A school-level survey involving more than 300 students from all years of study gave their feedback on the effectiveness of using the lab practical videos for their learning. 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.

In Figure 6a, 80% of the students strongly agreed and agreed that the videos were useful in helping them to connect the theoretical knowledge they gained from the asynchronous learning contents and synchronous online tutorial lessons. This is important especially in an engineering context where theoretical knowledge gained will not suffice if the students want to find solutions to solve real-world problems. The 84% of the students strongly agreeing and agreeing in Figure 6b on the usefulness of videos as reference when doing the actual lab experiments aligned with the intended purpose of the lab practical videos.

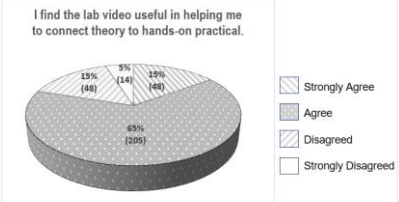

Figure 6a. Connecting theory to hands-on practical

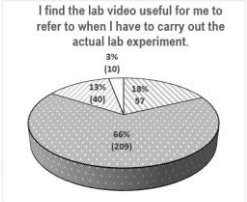

Figure 6b. Familiarity with actual lab experiment

During the creation of the lab practical videos, the length of the videos were kept intentionally short to enable “bite-sized” learning. This provides the flexibility for students to focus on the specific parts of the lab practicals which they are not familiar with, and to watch and review any specific sections again anytime they wish. As shown in Figure 6c, 86% of the students strongly agreed or agreed that the duration of the videos were just right.

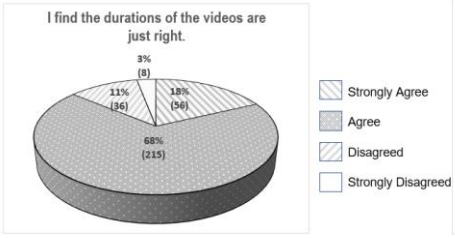

Figure 6c. Aspect of Micro-learning

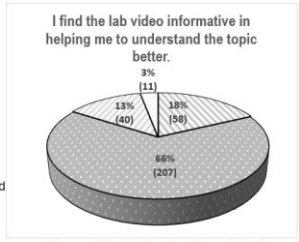

Figure 6d. Understanding of topic

A total of 84% strongly agreed and agreed that the lab practical videos were informative and helped them to understand the topics better as shown in Figure 6d. However, Figure 6d reveals that 16% of the students thought otherwise. This could be addressed in future work as these videos could be improved to make them more useful for students’ learning by incorporating aspects that engage them in higher order thinking and repetitive practical tasks, as more Level 2-type and Level 3-type lab practical videos would be created. Through virtual “hands-on” and improvement in details of the videos, better knowledge transfer and learning efficiency could possibly be achieved.

Survey on E-Proctoring Assessments

A school-level survey, consisting of 3 statements related to the assessments, with a 4-point Likert scale and two open-ended questions, was administered soon after the completion of the cMST in June 2020. A total of 338 valid completed responses was received.

Figure 7 shows the responses of the students on their views of the online assessment. 26.3% of the students strongly agreed that the regular assessments help them to keep pace with their learning, while 61.2% agreed on this. Combined, about 12.5% disagreed and strongly disagreed to this.

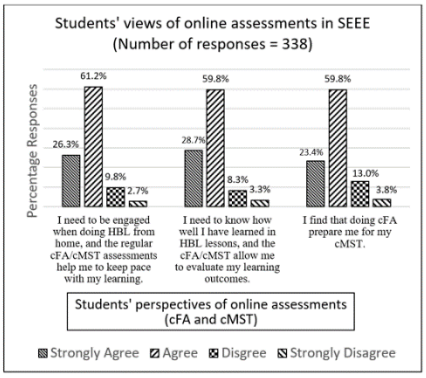

Figure 7. Results of Online cFA and cMST survey

A slightly lower percentage of 59.8% of students agreed on whether the cFA allows them to evaluate their learning outcome and how well they have learnt while another 28.7% strongly

agreed to this view. The combined 11.6% of students who disagree and strongly disagreed is lowest here. On the statement that doing cFA prepare students for the cMST, this recorded the highest combined percentage of 16.8% who disagreed or strongly disagreed.

Summary of Survey Results

Based on the summary given in Table 4, the results suggest that the School's quest to build an alternative ecosystem to support teaching and learning on a virtual platform is moving in the right direction as the students had given their endorsements based on the feedback received. This means that the students have accepted the asynchronous lectures, synchronous online tutorial lessons, and e-practical lessons as the new normal in their learning. With acceptance, they would tend to put in efforts to become more engaged in their online learning and this could only lead to positive outcomes. Indeed, as the students became more effective in their independent and self-learning, they had also strengthened and raised their SDL competency to a higher level. This encouraging result was further affirmed as similar academic performances for all modules were obtained at the end of Semester 1 in 2020, not unlike those in the preceding years prior to the pandemic.

Table 4. Summary of results of the surveys

Survey Questions	Agreed
Effectiveness of HBL asynchronous online lessons	85% (average)
Effectiveness of HBL synchronous online lessons	82.5 (average)
E-Practical lessons helped in connecting theory to hands-on	80%
E-Practical lessons helped in familiarising with actual lab experiment	84%
Lengths of e-Practical videos were just right for micro-learning	86%
E-Practical Lessons helped in the understanding of topic	84%
Regular assessments helped to keep pace with learning	87.5%
Regular assessments allowed evaluation of learning outcomes	88.5%

SURVEY ON SDL INDEX MEASURING PROGRESSION IN SELF-DIRECTEDNESS AFTER TWO YEARS

The results of this undertaking after two years of implementation is shared here. The students in Year 1 of cohort 2019/2020 were asked to participate in three self-assessments surveys so far; one when they first joined the School, a second and third respectively at the end of the first and second academic years. This is to investigate the students' SDL readiness at different milestones of their studies. Results from the first two surveys (at start and end of first year of studies) were shared previously (Toh, Chia, Tan, & Safura, 2020).

The self-assessment survey consists of 14 statements (see Table 5) on a 7-point Likert scale. The set of statements can be divided into three groups, the first two groups relating to intrinsic and extrinsic motivations respectively, and the remaining ten on SDL readiness, adapted from the work by Tan, Divaharan, Tan and Cheah (2011) on students' assessment of their SDL.

Table 5. Students' Self-assessment Statements for SDL

Statements S1-S2 Intrinsic Motivation	
S1	I prefer learning materials that really challenge me so I can learn new things.
S2	I prefer learning materials that arouse my curiosity, even if it is difficult to learn
Statements S3-S4 Extrinsic Motivation	
S3	I want to do well in my studies because it is important to show my ability to others.
S4	Getting a good grade is the most satisfying thing for me.
Statements S5-S14 Dimensions of Self-directedness	
S5	I set learning targets for myself.

S6	I normally ask questions when I am not sure about my learning.
S7	I always look for more information to help me understand better.
S8	I always make a list of what I need to do for my learning.
S9	I usually complete my assigned tasks on time.
S10	I often try to understand where I go wrong in my learning.
S11	I try different ways to solve problems on my own at all times.
S12	I have a habit of applying what I learned to other topics or areas.
S13	I always seek out what is required of me beyond the syllabus of my module.
S14	If I try hard enough, I will understand the learning materials.

In terms of intrinsic motivation based on the plot given in Figure 8, the students have shown positive improvements. For example, for S1, there have been an increase of 9% at the end of the second year. Likewise, for S2, it jumps from 56% to 69% meaning an increase of 13% of the students are motivated enough to want to learn out of curiosity regardless of the difficulty level. Similarly, in terms of extrinsic motivation based on S3 and S4, improvements are also evident as the percentages rise from 59% to 64% and 68% to 78% respectively in relation to showing one's ability to others and personal satisfaction in getting a good grade.

Figure 8. Students' self-assessment indicating heightened motivation

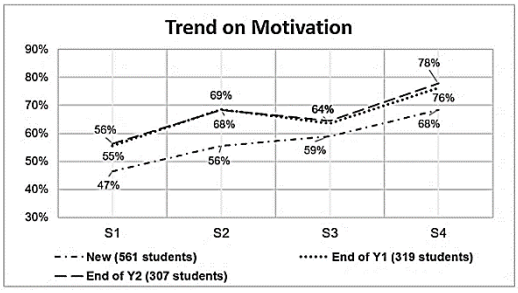

Figure 9 shows the results for all other statements (S5 to S14) evaluating the dimensions of self-directedness in the students. It is noteworthy that the overall trend shows the students have progressed well over the two years. Compared to the time when they first joined the school, much progress was made at the end of the first year and further strengthened at the end of the second year. The improvements ranged from 12% to 23%.

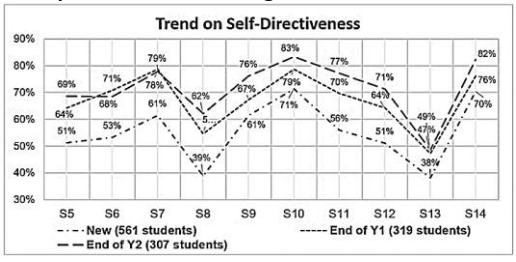

Figure 9. Students' self-assessment indicating heightened self-directedness

The biggest improvement of 23% was for S8 indicating that many of the students always make a list of what they need to do for their learning. Another notable jump of 21% was for S11, highlighting that students have developed the good habit of trying different ways to always solve problems on their own. There was also an increase in the number of students who sought to apply what they had learned to other topics or areas as S12 had garnered an improvement of 20%. The only drop from the end of first year to end of second year was in S6. A possible factor could be with the replacement of face-to-face with asynchronous lectures, students could now access online learning materials at any time of their learning without the need to refer to their lecturers to ask questions.

CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

Based on the work done during the pandemic with regards to the blended flipped learning materials for asynchronous lectures, synchronous online tutorials, e-practical lessons, and e-proctoring assessments, this heralds the opening of many exciting opportunities for the School. This includes enabling the school to explore full HBL across the semester to further optimize on the lab practical videos, online lectures and assessments that were developed.

Through the implementation of the fully online assessments and conducted through remote e-proctoring means, the School has gained useful experience and confidence, and nimble enough to adapt to the new online teaching and learning environment in a relatively short time. Conducted with the aim of engaging students in their learning, the innovative online assessments have enabled evaluation of learning outcomes by teaching staff, and students themselves, through constructive alignment of desired learning outcomes and re-designed teaching and learning approaches, while upholding the high standards of both academic rigor and academic integrity. The views and responses of the students are useful inputs to be considered for improving the implementation to bring about even greater student engagement going forward.

The findings from the self-assessment surveys by the students have affirmed the cultivation of SDL and showing the whole-school approach is progressing on the right track. When the pandemic struck at the beginning of their second year of study, the students were able to cope well as they had developed a certain degree of self-directedness in their first year. This certainly helped when they were forced into a two-month-long lockdown and had to comply with subsequent measures introduced in the classroom for safe-distancing after the lockdown was lifted. Indeed, at the end of the second year in the midst of the pandemic, it is heartening to note that the students' learning had not been affected by the pandemic but instead it had provided them with the opportunity to further strengthen their self-directed learning.

Although most students still very much prefer to have face-to-face lectures, the changed process they have undergone, whether they are conscious and willing participants or not, goes towards cultivating them to become self-directed and life-long learners to ensure continual employability in the twenty-first century workplace. Indeed, results of the SDL surveys have given the School the confidence to continue with the measures introduced during the lockdown even when the pandemic ceases to be a threat. With the asynchronous lectures, synchronous online tutorials, e-practical lessons, and e-proctoring assessments underpinned by the CDIO framework, the School is now ready and fully prepared to face any future pandemic threats without compromising on the cultivation of SDL in its students.

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BIOGRAPHICAL INFORMATION

Toh Ser Khoon is 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.

Chia Chow Leong is a Deputy Director at the School of Electrical & Electronic Engineering, Singapore Polytechnic. His current portfolio is in Course Management and Student Development. He oversees the planning, development and implementation of full-time courses and continuing education & training (CET) courses in his school. He has a strong interest in conducting action research to enhances students' learning and strengthen staff pedagogical competence. He also plans programmes to nurture students and develop them to become self-directed learners.

Tan Hua Joo joined the Singapore Polytechnic in 1991, serving in various portfolios such as Academic Resource & Development Manager, Course Manager and Head of Teaching & Learning (T&L) Unit. His interest is in T&L matters particularly in nurturing and developing students to become independent learners. He is also passionate about using educational technology in his teaching to help the students in their learning.

Safura Anwar has been with Singapore Polytechnic as a lecturer since 1986. After serving in various portfolios, she presently works with a team of highly experienced and dedicated staff in the Teaching and Learning unit in the School of EEE, who share a common passion to work with colleagues and students alike, so that they become better self-directed learners in all aspects in their own capacities and to role model SDL for others.

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