USING LEARNING ANALYTICS IN MOULDING STUDENTS TO BECOME SELF-DIRECTED LEARNERS

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ABSTRACT

The twenty-first century workers need to be able to constantly keep abreast with changing technology and possess the desired behavioural competencies to have a long, rewarding career. To help the students of the School of Electrical and Electronic Engineering (SEEE) of Singapore Polytechnic, to grow, serve and thrive in the new norm in this VUCA world, an enhanced engineering education model is needed, which incorporates lifelong learning, addressing the demands of deep skills, versatility, entrepreneurial vigour and a global mindset for the betterment of Singapore. This paper shares the comprehensive approach taken to refine the current holistic education model that incorporates the polytechnic's Self-Directed model, into its CDIO-based curriculum for the diploma programmes, and extending into the co-curricular activities (CCAs) offered by the School and the polytechnic. Cognizant of the challenges of the SDL initiative, the different workgroups within the School, articulate how their respective work areas contribute towards helping students to become self-directed learners. This helps to surface academic staff's understanding of the notion of self-directed learners, how their work areas are already contributing, and where these actions can be further improved, to achieve the common goal. With this in place, the school hopes to gauge whether the whole school approach has contributed towards students' progress in becoming self-directed learners. For this purpose, the School plans for what is termed provisionally, the Self-directed learning (SDL) index, to add to the commonly used Grade Point Average (GPA). This requires that students provide their self-assessment on various aspects of self-directed learning. Although it is a three-year project, this paper aims to share the work progress, learning and findings at the end of its first year. Learning analytics will be used to provide feedback on the progress of the students at appropriate stages and the end of their three-year-long study.

KEYWORDS

Self-Directed Learning, Learning Analytics, Whole-school, Standards 2, 10

INTRODUCTION

Technology disruption is the new norm in this VUCA (Volatile, Uncertain, Complex, Ambiguous) world of the 21st century. Today's graduates can no longer expect that the knowledge and training acquired through completing formal academic programmes in institutions of higher

learnings (IHLs) like the polytechnics or the universities, are enough and able to see them through their entire working lives.

To be able to meet the challenges of technology disruptions, they will need to become self-directed learners, with the ability to continually upgrade their skills and knowledge through a life-long endeavour to learn, unlearn and re-learn throughout their career, as pointed by Medel-Añonuevo, Ohsako & Mauch (2001) that "Today it is no longer enough to have the same living and working skills one had five years ago".

An enhanced engineering education model can help the students of the School of Electrical and Electronic Engineering in the Singapore Polytechnic to meet the challenges of the the 21st century workers, as shown in the Integrated Engineering Experience – Education for the Future" model of Figure 1, which incorporates lifelong learning, addressing the needs of deep skills, versatility, entrepreneurial vigour and a global mindset for the betterment of Singapore. In short, the focus is to nurture and develop students in three areas - academic, technology and leadership & service.

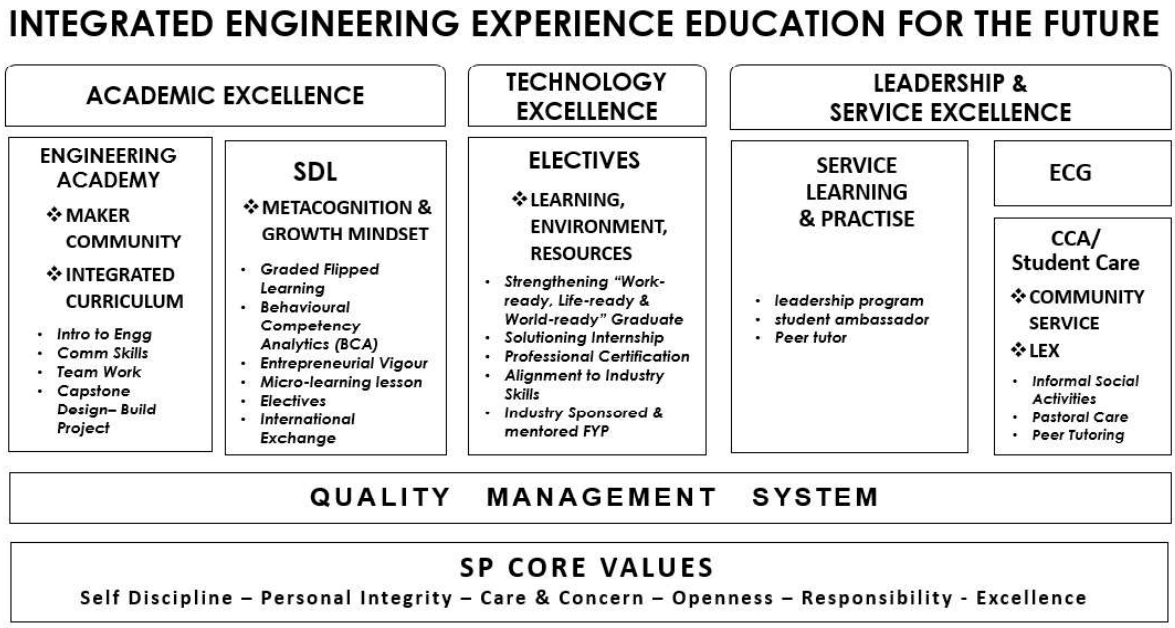

Figure 1. SEEE's enhanced engineering education model

The model is a comprehensive approach to enhance the current holistic education model that incorporates the polytechnic's Self-Directed Learning framework, strengthening the School's' CDIO and Design Thinking (DT)- based curriculum for the diploma programmes, and extending into the co-curricular activities (CCAs) offered by the School and the polytechnic.

SEEE values every student who invests three years to pursue a highly recognised engineering diploma qualification in SEEE. What will make the SEEE graduate more successful as compared to his or her peers, is that the person must display a set of highly valued and observable behaviours or traits which all employers will look for in a 21st century employee. SEEE terms this set of behaviours, the EEE DNA (Figure 2), comprising of ten key traits, namely Constantly Curious, Communicate with Impact, Be Versatile, Growth Mind-set, Global Mindset, Entrepreneurial Spirit, Deepen Skills, Give Your Best, Be Lifelong learner, and

Passionate in Engineering. The DNA elements were developed after many rounds of conversations involving teaching staff and students. SEEE is arguably possibly the largest and leading engineering education provider in Singapore with about 2600 full-time students enrolled.

This is mirrored to some extent by Vest (2005) who remarked that "students are driven by passion, curiosity engagement and dreams" and further added that "making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details."

Through different platforms such as co-curricular activities, national and international competitions, community service projects, leadership development, overseas attachment or exchanges developed within the School, as well as through collaboration with other stakeholders, SEEE aims to maximise the potential of every student that comes through its doors, thereby nurturing these curious minds and producing passionate engineers for the nation. Not limiting its students to teenagers but extending to working adults as well, the polytechnic for all ages aims to produce graduates who are work-ready, life-ready and world-ready. Such a highly-skilled engineering workforce will then able to support Singapore's economic growth and aspiration towards transforming the nation to meet future challenges. (Smart Nation: The Way Forward, 2018).

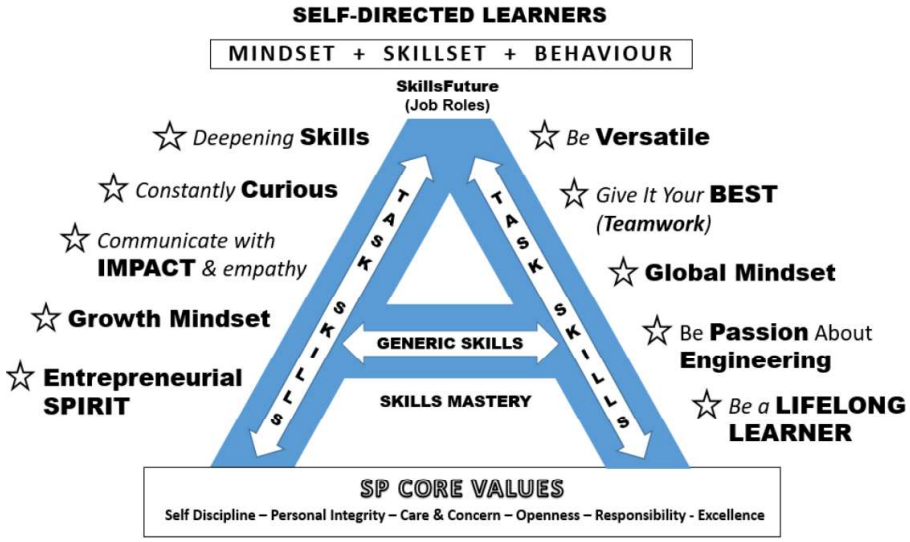

Figure 2. Desirable traits and EEE DNA

SELF-DIRECTED LEARNING IN SINGAPORE POLYTECHNIC

One of Singapore Polytechnic's collective aspirations is then, that beyond just imparting knowledge and skills, it reiterates the academic staff's role in the holistic development of the students, necessarily including that of shaping them to become self-directed learners. This was through the implementation of a Self-Directed Learning (SDL) Framework as shown in Figure 3 (Leong, Chan, & Chong, 2019) as a key initiative at the institutional level in 2018.

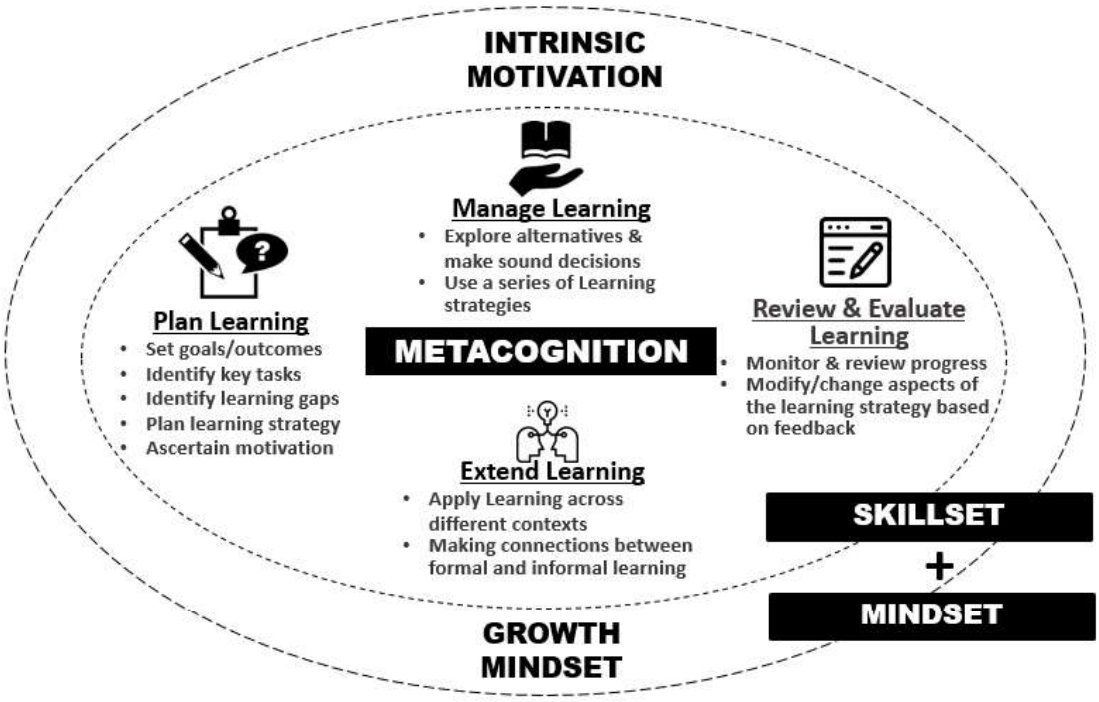

Figure 3. SP Self-Directed Learning (SDL) framework

The SP's SDL framework makes explicit the stages of planning, managing, reviewing and extending learning for the learner, echoing the definition offered by Knowles (1975) for self-directed learning as a process where the individual learner takes the responsibility and accountability for one's learning. This process essentially comprises the following: diagnose one's learning needs, formulate learning goals, identify resources to meet these goals, opt and put in place learning strategies and evaluate outcomes of the learning goals.

Gibbons (2002) reminds on the importance of the learner taking personal ownership of the learning, and the motivation to pursue and persist in the learning process by the learner, including that of extending learning, by making links, including those within formal and informal educational settings.

Tan and Koh (2014) suggested that self-directed learning could be better understood as occurring on a spectrum, ranging from the lowest level of SDL readiness to that of the highest; the lowest being incidental self-directed learning, and that of the highest, with high ownership of the various aspects of SDL.

For SEEE, the need to incorporate the SDL framework is aligned with its adoption of the CDIO framework for the implementation of the curricula of the various diploma courses that it offers. In the CDIO Syllabus, Part 2 covers the personal and professional skills and attributes expected of the engineering graduate, and the stages identified in SP's SDL model are reflected in 2.4.5, 2.4.6 and 2.4.7 of the CDIO syllabus.

DEVELOPING SELF-DIRECTED LEARNERS THROUGH A WHOLE-SCHOOL APPROACH

Figure 4 shows SEEE's whole-school approach to mould its students towards SDL, throughout the students' three-year-long studies. The journey begins during the freshmen orientation programme to welcome new students whereby the communication between the School management, comprising the Director, Course Managers and Pastoral Care Tutors, and the new students take place. The whole-school approach is conveyed to the students, alongside the school's goal and mission to imbue and nurture the new students towards becoming self-directed learners by the time they graduate from the diploma courses at the end of their studies, including the EEE DNA shared earlier.

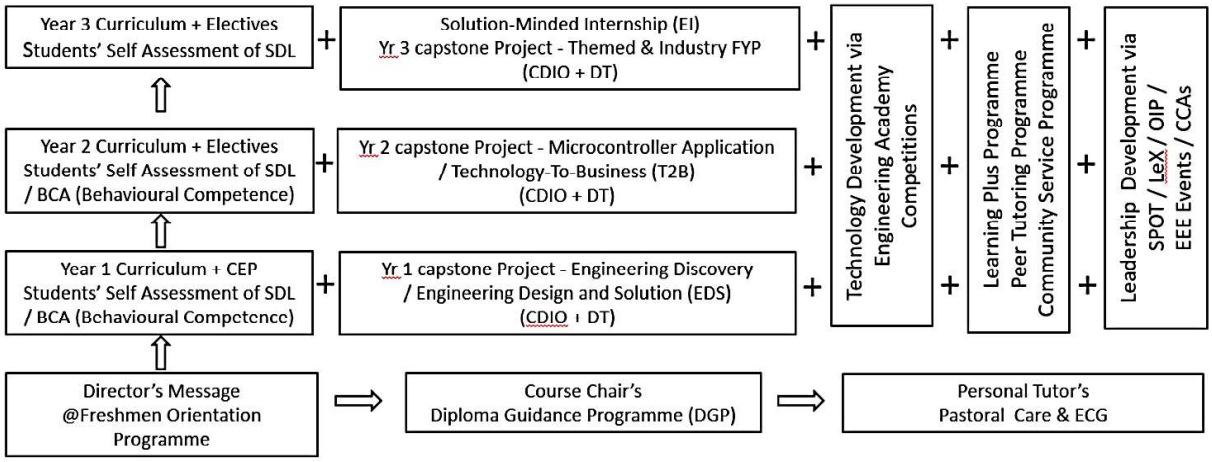

Figure 4. Whole-school approach to develop self-directed learners

The curriculum in all the three years of study is designed to build up their independent, meta-cognitive learning skills through flipped learning with self-assessment analytics of SDL. Also, integrated projects in each of the three-year course of study help to develop the students in two areas – to apply the theoretical knowledge they have learnt into practice, and to improve on their personal and interpersonal skills including teamwork and communication skills which are key employability criteria (Part 2 and 3 of the CDIO syllabus). Community service programmes and other events such as overseas immersion programme, service-learning experiences in overseas rural communities and CCAs all seek to transform them to become work-ready, life-ready, empathetic in their outlook, generous and caring towards the less fortunate.

The School also further translates SP's SDL framework and contextualized the framework for the engineering curriculum as shown in Figure 5. This modified framework was the result of several discussions between teaching staff and students.

Based on the school's interpretation, students who become self-directed learners possess a growth mindset together with the metacognition ability. To have a growth mindset, they need to be intrinsically motivated in their outlook coupled, underpinned with a passion for engineering. With a growth mindset, these will spur students to be innovative, looking at challenges from a wider perspective and always searching for creative solutions to existing or future challenges, helped by their ability to plan, manage, review and evaluate and extend their

learning. With this ability, it helps in the acquiring of new knowledge that is indispensable in facing the unknown challenges of the future.

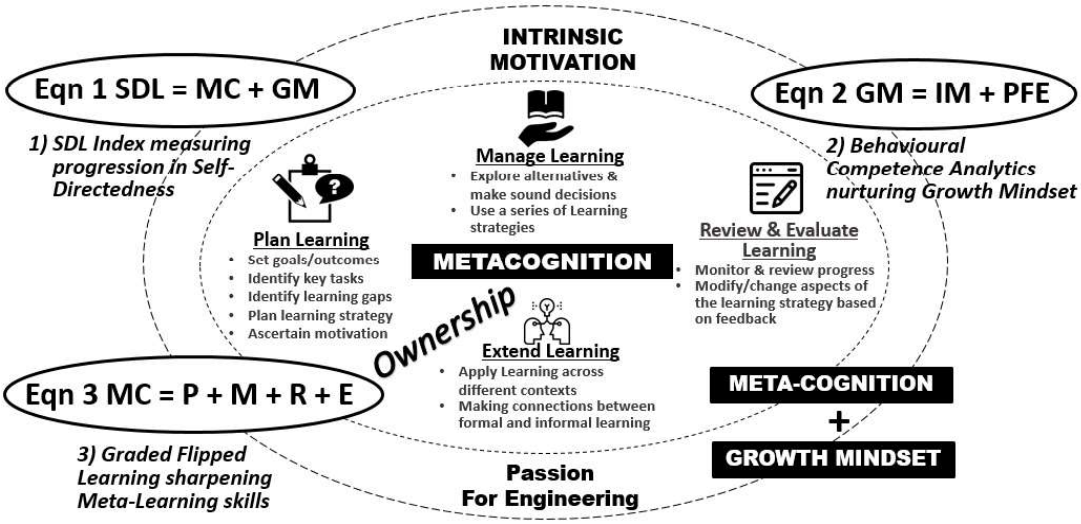

Figure 5. SEEE's SDL Framework, contextualizing SP's SDL Framework for an engineering curriculum

SDL ECOSYSTEM

For a School with a staff strength of 180 staff, there are various divisions, sections and staff workgroups, each with its objectives, and within the respective spheres of influence. However, collectively, the ultimate goal is to mould the students to become self-directed learners.

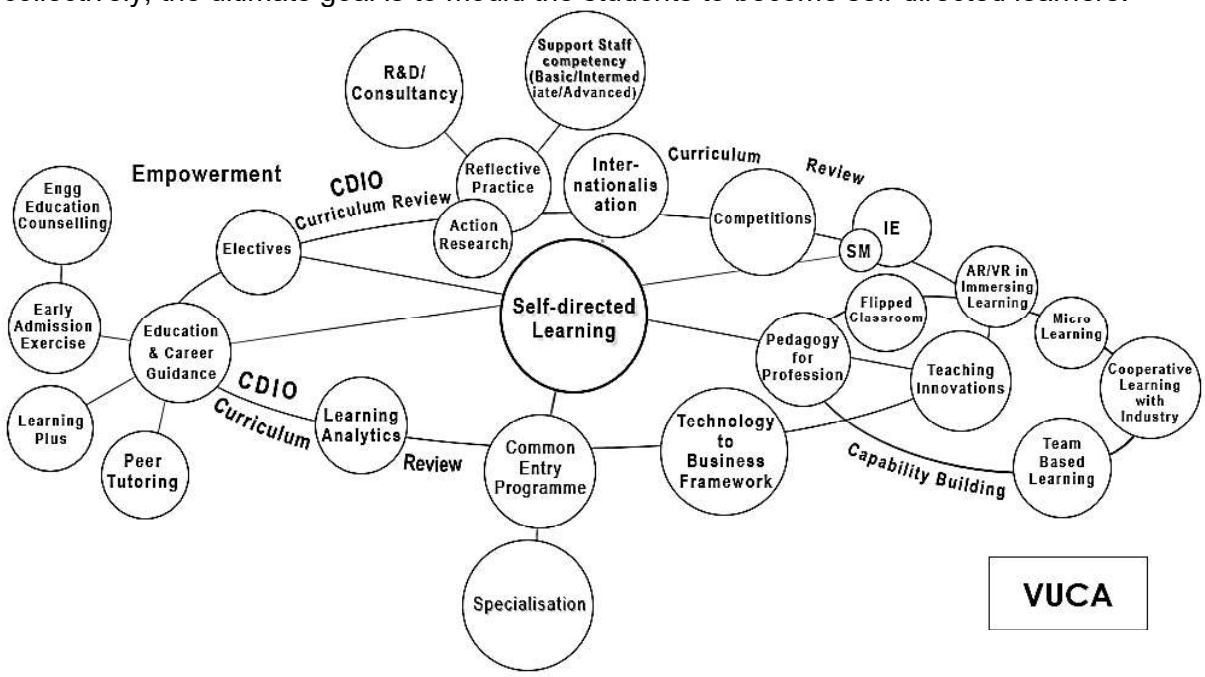

Figure 6. SEEE's SDL ecosystem

Figure 6 shows the SDL ecosystem detailing the interconnection of the different work areas that contribute towards the goal of SDL after a comprehensive review of the prevailing workflow in the entire school. The SDL ecosystem espoused by the School is in line with the notion that self-directed learning can take place in various contexts, and the essential role of the academic staff is to put in place by design so that self-directed learning can take place within these contexts.

The kind of ecosystem that the School posits is suggested in the work done by Tan & Koh, 2014, which considers self-directed learning as taking place both within and outside the formal school setting, with students potentially benefiting from both structured and unstructured learning experiences. Essentially, these broad contexts of learning are as follows: both in-school and out-of-school settings with structured learning experiences, led by academic staff; and in-school and out-of-school settings with unstructured learning experiences primarily carried out by the students.

For both in-school settings, examples of academic staff undertaking reflective practise and teaching innovation exemplify the in-school settings with structured learning experiences for the learners. To further illustrate, one example of this out-of-school setting, would be the solution-minded internship undertaken by all students in Year 3 of the studies, with a structured internship programme offered by the companies. The experiential learning experiences of learners through such out-of-school or out-of-the-classroom settings may offer scope to prepare students to be self-directed (Jiusto & Dibiasio, 2006).

In the following sections, several aspects of the whole-school approach outlined in the SDL ecosystem in figure 6 above are shared and how the learning experiences garnered in the settings, as articulated by the various workgroups, help shape the students towards being self-directed in their learning.

Reflective Practice (RP) & Action Research (AR)

Through RP, academic staff question their long-held assumptions of students' learning challenges, and their usual teaching practices, to help their students learn better. This extends beyond content and assessments, intending to get their students to think about their learning. Through AR, teaching staff take their reflective practice further. They critically examine their own accepted usual teaching approaches and practices, systematically and carefully collect data, analyse the data, and act on what they learn and work collaboratively with fellow teaching members on implemented interventions. These are shared with colleagues and papers proposed on the action research undertaken. Teaching staff look for evidence-based T&L interventions and approaches, including technologies that push the boundaries of how students learn, and how these are used in the changing educational landscape. They explore and adapt these to their teaching practices to help their students towards being self-directed learners. Sharing of reflective practices amongst teaching members and publication of action research work are testimonies to the good work achieved. Ultimately, improved teaching practices will help students to become SDL.

Teaching Innovation (TI)

Lecturers take on "deepening pedagogy" goals which allow them to review and implement innovative pedagogy or technology, to improve the students' learning experiences. They are also involved in "reflective practice", whereby there is intentional and regular reflection on the effectiveness of teaching and learning interventions, strategies, pedagogy or technology used in the classroom. Academic Mentors (AMs) research teaching innovation and present

their findings at international and regional conferences (e.g. CDIO, ISATE, IEEE etc). Currently, engaging content is effectively delivered to full-time and adult students over the Internet. Flipped teaching is progressively implemented over the three years for all courses to train the students to become independent learners and sharpen their metacognitive attributes. Data-driven approaches in teaching and learning, using analytics will be increasingly leveraged to enhance SDL.

R&D / Solution-minded Internship

Students as interns take charge of their learning as they manage and deliver industry project/s within the 22-week-long internship in an assigned company. Using CDIO/Design Thinking (DT) approach, the interns sharpen their skills in planning, managing, reviewing and evaluating, and extending their learning in their internship. This contributes to the sharpening of their metacognitive skills that is part of SDL. The technical outcomes of their industry projects demonstrates their R&D skills.

Pieces of evidence pointing to the successful completion of the internship are from internship journals that capture the interns' SDL journey; feedback from the employers highlighting the value of the work tasks and/or projects created and deployed, and possible scholarship awarded to the interns as well as employment opportunities for the interns.

Competitions

Students competing in international and local competitions sharpen their skills through training where they plan, manage, review and evaluate and extending their learning based on a set of competition criteria. The training under the guidance of academic staff as competition coaches and experts, provide opportunities for self-directed learning, given the open nature of competitions. Such highly charged and competitive environments drive the students in such programmes to take charge of their learning, giving them many opportunities to be self-directed especially since it is necessary to think on their feet in response to unexpected developments. The shortlisting for final rounds of competitions as well as the many prizes and awards won by the students are testaments to the students successfully embracing and developing the SDL qualities.

Internationalisation

This provides many opportunities for the students to benefit in the following ways: broadening and developing global perspectives, social and cultural interactions and exchanges, networking and building global friendships and learning to be independent and self-sufficient while living and learning in a foreign environment.

Students on an international programme will have to take ownership of their learning by engaging in a project and/or completing a structured learning in different socio-cultural environments. In this way, they learn to adapt and thrive in an international environment, pushing their limits and gaining skills beyond the classroom. The students' global experiences captured in the students' reflective journal give details of their achievements and the value of the projects deployed in foreign settings gives a measure of how successful the outcome is. Internationalisation will help the school to produce graduates who are culturally sensitive and possess a global outlook with the ability to operate within multi-national and cultural settings.

Electives

Students take charge of their learning by shaping their learning paths and pursuing their passions. They have a choice of electives that allow them to broaden, deepen or further knowledge and skills. The polytechnic's Elective Framework is designed to provide the students with educational experiences aligned with the aspiration of developing self-directed, versatile and lifelong learners.

Common Entry Programmes & Specialisation

The common entry programmes offer a pathway for the students to spend one semester taking both electrical & electronic engineering and mechanical & aerospace engineering modules so that they can make informed choices in choosing their preferred courses that are aligned with their interest. Before making the decision, they exercise self-directedness by exploring online resources and getting advice from seniors and lecturers on the courses offered.

Technology to Business (T2B) Framework

It aims to inspire Diploma in Engineering Business (DEB) students to be technology entrepreneurs by providing a hands-on introduction to the entrepreneurial process of discovering, evaluating, exploiting and implementing the opportunities with existing and/or emerging technologies and develop them into potentially viable businesses. Students will apply CDIO and Design Thinking to conceive the solutions/services and finally operate on them. Furthermore, they will learn to create value propositions, assess risks and develop project plans as an integral part of their projects by developing the entrepreneurial mindset and attitude to bring their solutions/services to the next level. With the training, this group of students will develop the confidence to work in start-up companies or MNC with start-up venture activities. Others will acquire the conviction to spin-off their solutions/services to start-up companies. This enterprising opportunity further develop the students' self-directed learning.

Education & Career Guidance (ECG)

The ECG platform provides students opportunities in discovering and understanding their values, interests, personality and strengths and creating their brand. The Learning Plus programme complements by helping students to understand the kind of skills and competencies required in the workplace through industry exposure, workshops and exhibitions. Personal Tutors help to motivate and inspire students to meet their full potential. In this way, the soft skills nurtured in the students, industry and academia exposure and social community engagement will serve to enrich the students holistically in their development. Together with their academic results and imbued with the school's DNA, the graduates can apply for university places or jobs with a good resume and portfolios.

Student Leadership Development

As the students lead, plan and execute events from school to international level, the network and learn how to communicate, help each other and work together in a team. They also volunteer, serve, and contribute back to school and social community through various activities. The rigorous and intensive Singapore Polytechnic Outstanding Talent programmes and SEEE Ambassadors activities nurture and develop the selected group of

students to become more confident and competent in dealing with social challenges. Service-learning in the peer tutoring program provides an opportunity for the weaker students to learn good learning strategy from peer tutors who are senior students. The peer tutors have leaders who will mentor and guide other tutors on commitment, responsibility, patient and caring in carrying out their duties to help the weaker students. Another area for leadership development is in community service. It provides the students with the learning opportunity in planning and coordinating as they work as a team to implement interactive activities with the community. As they engaged the community during the activities, student learn better to be more empathetic in their approach and outlook.

USING LEARNING ANALYTICS TO MEASURE SELF-DIRECTED LEARNING

Learning Analytics is defined as " the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" by the Society for Learning Analytics Research. The use of learning analytics in education and the actual outcomes and impact are somewhat varied and could be clearer as suggested in the literature review (Viberga, Hatakkab, Bältera, & Mavroudia, 2018) (Wilson, Watson, Thompson, Drew, & Doyle, 2017). The need for effective leadership for the development and deployment of learning analytics is also recommended by Andre, Le, & Webster, 2019. The kind of use of the learning analytics in the School's case would be akin to the lifelong learner modelling proffered by (Kay & Kummerfeld, 2012), through on a very modest scale. This refers to how data gathered from different learning environments will be archived as the learner's learning activities that can provide an image of the learner's learning journey in life.

Here the School hopes to use learning analytics to address the question of whether and how effective the whole-school approach has achieved its intended objectives. To address this issue, the school decides to look into the students' SDL readiness at different stages of their courses through self-assessment by the students. This consists of 14 statements, using a 7-point Likert scale, as shown in Figure 7. 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.

The first self-assessment was conducted when the students enrolled into the polytechnic. Based on the roadmap, the subsequent assessments are targeted for implementation when the students complete their Year 1 in April 2020, Year 2 in April 2021 and Year 3 in April 2022. The results obtained each year would be compared to see whether the trainings received have made a positive impact on the students' self-directed learning.

The first survey was conducted in April 2019 and the results are shown in figure 7 below. About intrinsic motivation, 47% indicated that they prefer challenging learning materials and another 56% prefer learning materials that arouse their curiosity even if they are difficult to understand. For extrinsic motivation, 59% would like to do well in their studies so that others would have a favourable image of their abilities. A high percentage of 68% agreed that getting a high grade is a most satisfying personal experience. Trying to understand where mistakes were made in their learning to improve garnered the highest percentage of 71%. When it comes to seeking out what is required beyond the syllabus of the module, a low percentage of 38% was registered. As the favourable response ranged from 38% to 71%, this shows that there is room for the school to sharpen their SDL skills during their course of study.

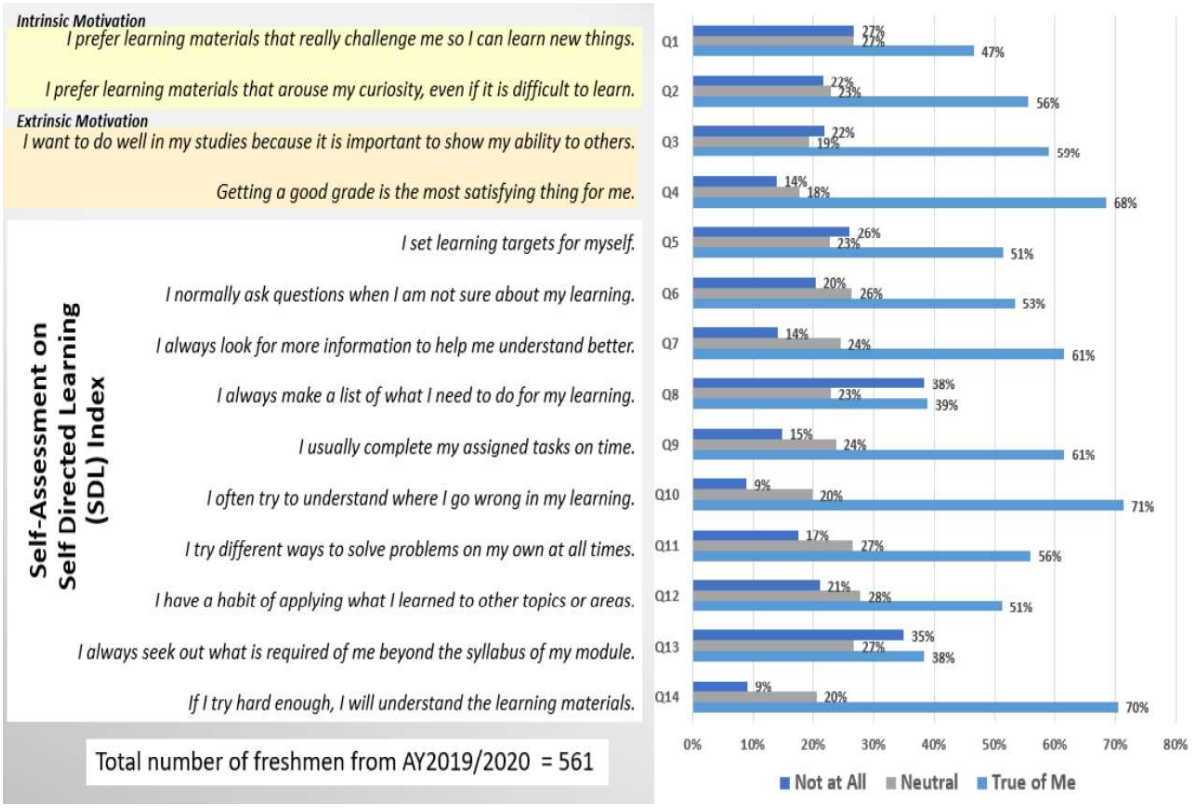

Figure 7. Self-assessment on SDL Readiness and Results of Survey of Year 1 Freshmen

Through the data obtained at different stages of the students' journey, the use of learning analytics intended for use up to this point is more like a tool for quality assurance and quality improvement of the whole-school approach as put across by Sclater, Peasgood, & Mullan, (2016). The term SDL index, mooted by the School, represents a score indicative and derived from the responses of the students, though its actual form may be considered in conjunction with other information.

Going forward, it could be possible that the data collected could also be used to show the progression of students in being SDL, vis a vis students' record of CCAs and other out-of-classroom settings achievements, recorded under the Student Administration System (SAS). This may contribute towards providing students with the profile of the success story of a self-directed student, along the lines suggested by Sclater, Peasgood & Mullan, 2016, to help encourage the right behaviours of the students.

LIMITATIONS

The approach outlined thus far, has possible limitations. The need to validate the student self-assessment questionnaire on SDL is recognised. For the self-assessment by the students, there could be situations whereby some of the high-achieving students place higher demands on themselves and rate themselves lowly on the self-assessment, and some of the low-achieving students may have a blind spot in terms of their capabilities and thus rate themselves highly on the self-assessment. This issue will be addressed by another ongoing project called

"Behavioural Competency Analytics" that seeks to gather feedback from teaching staff for correlation with the students' self-assessment. To date, the first stage of the study is completed based on the roadmap. As more results will be received, compiled and analysed in subsequent years, it would then be possible to identify specific areas of the whole school approach, which contributes positively or otherwise, towards shaping students to become self-directed learners.

CONCLUSION

The paper presented the school of EEE's SDL framework with the ecosystem established and the adoption of the whole-school approach. The first set of data in figure 7 showed there is great potential in the students to become more self-directed. Using learning analytics and with more progressive data to be collected in the coming years, the effectiveness of the whole-school approach would be reviewed and assessed and for taking appropriate actions where required. This would provide the impetus for the school to continuously shape the students towards being self-directed learners and prepare them for the workplace of the future.

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BIOGRAPHICAL INFORMATION

Toh Ser Khoon 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.

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. As a senior lecturer, 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. As a senior lecturer, she has served various portfolios. Her appointment as an academic mentor since 2012 sees her working with students and colleagues alike to help students learn better.

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