SKILLS BUILDING TOWARDS SELF-DIRECTED LEARNING VIA ACTION RESEARCH REFLECTIONS

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ABSTRACT

In the fast-paced, changing global economy, it becomes increasingly important to develop self-directed learning (SDL) skills in our students to stay competitive and adaptive to the ever-changing needs. In support of more SDL teaching and innovation activities, Singapore Polytechnic (SP) has developed the SDL framework. However, many practitioners are unfamiliar with it. There is also currently a lack of knowledge of the appropriate ways of simulating and introducing SDL to our students. This paper thus aims to use a feedforward process where some interventions to promote SDL for our students were tested out. In the pilot action research, two instances of SDL strategies were carried out for 96 freshmen engineering students from Oct 2018 to Feb 2019. In addition, students were asked to do a simple self-assessment on SDL to see if they can use this as a tool to assess their SDL behaviours and suggest appropriate changes. To our surprise, 4 out of the 5 classes rated themselves significantly higher compared to their lecturer's rating of themselves. A simple follow up with the students and classroom observations revealed that many of them were seem multitasking during the lessons, and not revising what they have learned as regular as we would expect them to. We see these factors as the contributing factors that could hinder students from being more self-directed. Plans to improve on student's study habits thus become the focus for the next action research. We see that the use of action research methodology help us to kick start this journey. The continued use of this approach is believed to help educators design better lessons that are suited for our engineering student's profile, thus effectively helping them to transit from being too dependent to more self-directed.

KEYWORDS

Self-directed learning, motivation, growth-mindset, problem-solving, active learning, programming, inquiry, meta-learning, debugging, Arduino, action research, learning strategies, Standards 7, 8

BACKGROUND

"Cher….. can you show me how to do this again?" How many times have we heard students asking similar questions like this? These observations were too common and familiar for teaching staff who have taught the 1st year Diploma in Computer Engineering (DCPE) students taking Introduction to Engineering 2 (IE2) module throughout the 15 weeks duration. This module is 3 hours weekly project-based module in which the students are expected to learn basic programming using the Arduino based Zumo robot and later work in pairs to battle opponents from their class and other classes in the final Zumo competition challenge. The objective of using the Zumo robot is to demonstrate that engineering is fun, rewarding, relevant, and interesting. It also helps students see the direct connection between the program as written and the visible behaviour of the physical devices, rather than as just a text printout on a screen. They will also be able to reflect on the effectiveness of their solutions and will be able to experiment to obtain alternative solutions and evaluate their effectiveness in comparison with each other.

What the teaching staff has commonly observed in the classroom is having a handful of students displaying a strong tendency to either seek their peers' assistance and/or expecting their lecturer(s) to provide direct solutions on a one-to-one basis. Some students were not even able to recall any of the preceding lessons and were always lost to begin with. Some students would ask the same questions again over time, while some would expect us to troubleshoot for them all their errors. Although we do have students who were very motivated, self-directed, and showed enthusiasm in trying out, experimenting, and having fun throughout the lessons, the number of students who displayed the mentioned learning dependency can be overwhelming for teaching staff to handle. In some cases, we observed panic and anxiety among the students, and the teaching staff has to guide them with considerable effort. All these indicated strongly that quite a number of our students were just not ready to take ownership of their learning. It thus leads to us thinking: "How can we cultivate the learning environment to support students to take more responsibility in their learning?"

THE NEED FOR SELF-DIRECTED LEARNING

Knowles (1975) described self-directed learning (SDL) as "a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes."

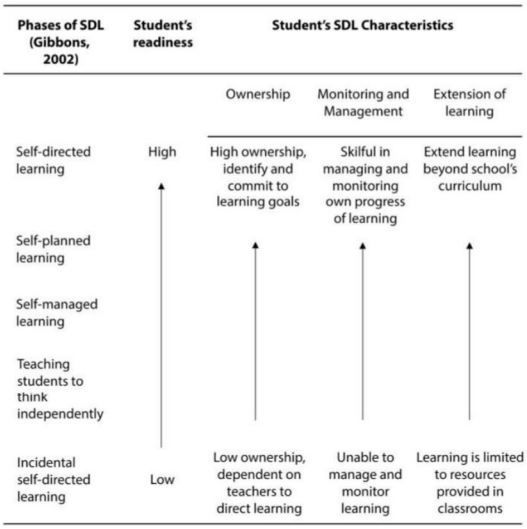


Figure 1. Gibbons' (2002) SDL Spectrum and Student's Readiness

To have a better understanding how ready our students may be for SDL, one can draw on Gibbons' (2002) work where SDL can be viewed as a spectrum that begins from the lowest level identified as "incidental self-directed learning" to the highest level termed "self-direct learning or SDL" (see Figure 1). These phases may not necessarily occur in a linear and hierarchical order. It is to indicate the progressive development of students' readiness in self-direction. Using the given definition of SDL and Gibbon's SDL spectrum, one can easily identify that our students were at different levels, with quite a handful of them falling into the incidental self-directed learning phases of SDL as they have exhibited behaviours that indicate low ownership. To prepare students for a world, we cannot even predict; our institution recently came up with the SDL framework, as shown in Figure 2.

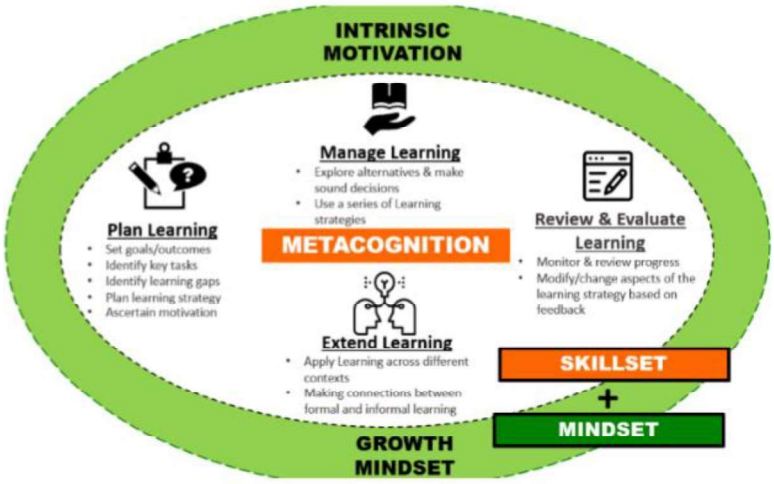


Figure 2. SP Self-Directed Learning framework

The SP's SDL model encompasses a range of cognitive and metacognitive skills. The key underpinning competence for students to become self-directed in their learning is to help the learner develop a growth mindset (Dweck, 2006) and Metacognitive Capability (Flavell, 1979) under the learning environment that can motivate learning (Ryan, 1980), which is often loosely defined as "thinking about thinking." To cultivate students to be more self-directed, the

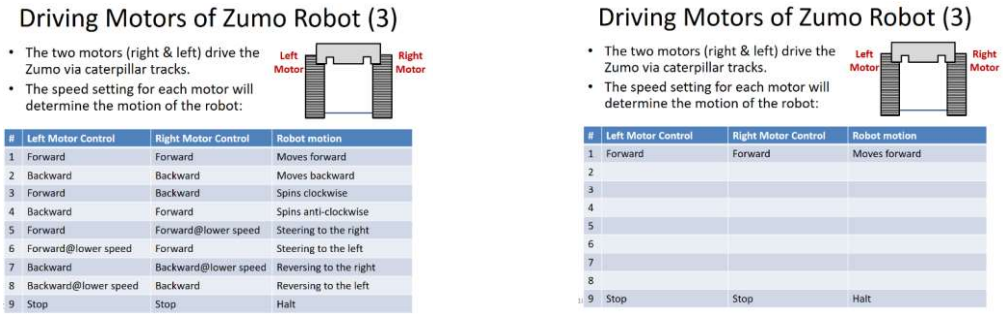
framework suggests, the learner needs to be able to plan his/her own learning goals, manage their learning by exploring a series of learning strategies and evaluate their learning where the students reflect on the effectiveness of their learning/thinking process and re-plan based on the evaluation. Lastly, the learner takes on a reflective process where he/she makes connections to other learning areas and analyse how their previously adapted strategies could be applied in another context.

The role of the teaching staff is, thus, vital to help students develop the necessary skills. However, as pointed by Csikszenthmihalyi (1997), goals should be sufficiently difficult and challenging to bring greater 254ulfilment in their accomplishment. If the goals are perceived to be overly challenging, it could lead to a high level of anxiety and unwillingness to give it a try. As one of my colleagues, after going through the SDL framework training session, told me: "It seems so complicated, I don't think I can do it!". Besides, the presence of so much new knowledge such as growth mindset, metacognition, and self-determination theory may leave educators confused and unsure about how to proceed, placing a heavy burden or mental barrier on already busy educators. Added to the challenge, there is currently a lack of knowledge of the appropriate ways of simulating and introducing SDL to our students.

This paper thus aims to use a feedforward process where some interventions were tested out to encourage students to be more self-directed. The action research methodology was adopted in this study to gather insights and observations in the pilot run. Insights and observations from the pilot run were then used to improve the next run. This becomes an iterative design process with the aim of us to design better lessons to help transit our students from being too dependent on a more self-directed learner.

THE PILOT ACTION RESEARCH

To address the observed non-self-directed learning behaviours in the classroom, a pilot action research to promote SDL was conducted from Oct 2018 to Feb 2019 for 96 1st year DCPE students taking the IE2 module throughout the 15 weeks long module. The SDL strategy began with the author giving the usual, and familiar teacher-directed instructions approach for the first two lessons followed by less and less teacher-directed instructions with increased questioning in the next 7 weeks. Figure 3 illustrates an example of a simple modification the first author has made in the PowerPoint slides that support less direct-instructed approach.



(a) Before (b) After

Figure 3. The simple modification of the PowerPoint slides for teaching staff to use more questioning and less direct-instruction approach.

In this particular instance, the author asked the students what all the nine possible Zumo Robot motions are; and how these can be achieved. Two examples were provided to start the thinking process, and it was observed that most of the students were excited to answer and able to fill in all the blanks with some hints provided. During this period, students were encouraged to track their understanding, identify their learning gaps, and ask as much as they could during the lessons with the end goal to win the Zumo competition. In the 2nd half of the module, we decided to place more focus on stage 2 of the SP SDL framework with simple motivation strategies to promote SDL opportunities to take place. For the remaining weeks, the students would work in pairs. A worksheet was also designed to guide the students in the planning of the Zumo competition. They would receive 5 tokens, which they could use, a token at a time, to ask questions if they need any clue, rather than directly receiving the answer during their preparation of the Zumo competition. This process aims to promote students to think before asking and help them to manage their expectations and adjust their learning steps from the very beginning. With this simple modification, we hope such an SDL strategy can increase students' ownership in taking care and managing their learning and be less dependent on their lecturers to provide direct solutions.

Students' Self-Assessment of SDL, Perceived Interest and Growth Mindset

Unlike learning programming skills, students can easily obtain feedback if they have achieved the learning objectives by testing their codes using the Zumo or from the text screen with the given learning tasks. It is, however, not so straightforward for students to know if they have become more self-directed. To introduce students how they can access their SDL behaviours and make appropriate changes, students from the 5 classes (1A24, 1A21, 1A22,1B02, and 1B03) were invited to complete the self-assessment on SDL near the end of their Zumo competition preparation. Items 8 to 11 questions were added to assess students' perceived motivation and growth mindset. 94 out of 96 students completed the self-assessment with the results shown in Table 1. The students were then asked to share, "What do you think you could have done to be more self-directed in your learning?" For this question, only 74 out of the 94 students' comments were relevant and valid. Their responses were collected and grouped into identical/similar meanings, as summarized in Table 2.

Insights and Reflections

In the first half of the module, the authors find that the less-direct instruction approach worked well and was considered a success. However, it was not always plain sailing, especially when only little direct instruction provided. In one instance, the students were first taught how to write a simple loop program to access all the contents in a 1D-array variable on the whiteboard. The students were then challenged to extend their understanding to try out by writing their program codes to access the contents for a given 2D-array. This was what was observed: some students struggled and got it; some struggled and failed; some others simply copied the programs from online resources without trying or/and understanding. Presumably, a few students displayed an attitude that as long as it worked, they have no desire to understand how it worked. Besides, weaker students, who think programming was a rather difficult task and abstract to learn, shared with us that they felt anxious and unsure of follow up despite hints were provided. Thus, appropriate direct-instruct instructions were still necessary at the end when students failed to figure out.

As seen, educators can encounter a situation like this even with simple adaptation to the teaching strategies. Even with attempts to troubleshoot and intervention, there may just be no easy solutions. Thus, it is important we do not implement strategies that may be too

overwhelmingly demanding for the students. In the attempt to strike a balance between students who find it just challenging and weaker students who panicked over the questions and challenges, a trial was made. When students faced similar struggles with the challenges presented to them, they were asked to recall what they have just learned. This seems to help them make connections to what they have learned, and more students were able to complete the mini-challenges. However, one must still be ready to provide more direct instructions if students were still struggling within a reasonable amount of time.

Table 1. Results of students' self-assessment of SDL, perceived interest, and growth mindset.

Q	Behaviours indication	1A24	1A21	1A22	1B02	1B03	Groups Mean
1.	I formulate questions and generate relevant inquiries.	3.4 (0.92)	4.06 (1.06)	3.63 (0.89)	4.16 (0.9)	3.9 (0.85)	3.83 (0.92)
2.	I try different ways to solve problems on my own.	4 (0.95)	4.26 (0.93)	4.06 (0.93)	4.89 (1.1)	4.35 (0.59)	4.31 (0.9)
3.	I try to understand what went wrong.	4.35 (1.09)	4.79 (1.03)	4.69 (0.95)	4.74 (0.81)	4.85 (0.88)	4.68 (0.95)
4.	I explore a range of possibilities and make sound decisions.	4 (1.17)	4 (0.94)	3.88 (0.96)	4.74 (0.81)	4.11 (0.81)	4.14 (0.94)
5.	I self-plan and self-manage my time well.	3.15 (0.88)	4.05 (0.97)	3.69 (1.14)	3.84 (0.6)	4.55 (0.83)	3.86 (0.88)
6.	I look for available resources to improve learning.	3.65 (1.09)	3.95 (0.91)	4.59 (0.80)	4.58 (0.77)	4.2 (1.20)	4.19 (0.95)
7.	I critically reflect on the effectiveness of my learning and gather feedback from my peers and lecturer(s) to achieve my learning goals.	3.75 (1.07)	4.43 (1.12)	4.00 (0.79)	4.21 (0.85)	4.2 (1.20)	4.12 (1.00)
	Overall average (SDL)	**3.76**	**4.22**	**4.07**	**4.45**	**4.31**	**4.16**
Perceived interest/Enjoyment (item: Q8)							
8.	The IE2 labs were interesting.	**4.15** (1.35)	**4.21** (1.36)	**4.41** (1.33)	**5.21** (0.85)	**4.2** (1.20)	**4.44** (1.22)
Perceived growth mindset (items: Q9, Q10, Q11)							
9.	I see making mistakes as learning opportunities.	4.63 (1.16)	4.42 (1.12)	4.81 (1.05)	5.05 (0.78)	4.9 (0.79)	4.76 (0.98)
10.	I see many opportunities for me to take charge of my learning.	4.4 (1.19)	4.32 (1.20)	4.41 (1.00)	5 (0.82)	4.4 (0.94)	4.51 (1.03)
11.	I believe I can manage/take charge of my learning. (G)	4.05 (1.57)	4 (1.25)	4.41 (1.06)	5.11 (0.94)	4.6 (0.94)	4.43 (1.15)
	Overall average (growth mindset)	**4.36**	**4.25**	**4.54**	**5.05**	**4.63**	**4.57**

*The assessment uses a 6-point Likert scale (1=not at all to 6 = All the time).

Items Q1 to Q7 were selected and taken from Tan, Seng Chee. (1965) and modified slightly ascribed to the study

Table 2. Students' comments on what they could have done to be more self-directed.

Response with similar/identical meaning	%	Selected actual written comments from the (N=74) students
Be more resourceful/Read up more (n=22)	27%	*"Research on the codes more at home."* *"Practice more coding to get familiar with the IDE."*
Poor time management (n=19)	26%	*"I could have managed my time better."*
To ask more questions (n=9)	12%	*"I could have to ask more questions."*
Pay more attention/not distracted in the class (n=7)	9.5%	*"not be distracted doing other things other than coding for the Arduino."*
Practice more(n=6)	8.1%	*"I could have explored more into how to code more strategy to be able to understand even better and try out new stuff."*
Understanding the codes(n=4)	5.4%	*"I should revise the chapters gone through in-class and redo the codes for better understanding."*
Late for class(n=3)	4.1%	*"Not be late and come earlier for lessons."*
Direction/goals (n=2)	2.7%	*"More concrete goals @ relative points of the project. Having a goal and ideas of what to do and complete."*
Preparation(n=2)	2.7%	*"I should have read through the day before to have more ideas at what is going on in class."*
Others (n=1)	1.4%	*"I should have been more confident in learning the language of learning how to code the Zumo and not relied on my partner."*
	1.4%	*"Allow more moments to discover and discuss with friends."*
	1.4%	*"Reflect & improve on past mistakes."*

In the 2nd half of the module, the actual practice of fostering effective SDL amongst students using 5 tokens to limit the questions the students can ask during their Zumo competition preparation period have mixed outcomes. The following are the brief observations for the 5 classes provided by the lecturer who is teaching them the module:

1A24 (Lecturer 1): The class enjoyed some part of the lessons but was always seem to have a short attention span. Some attempted to use the token to ask very general questions in the hope of getting as much help as possible. Some kept quiet, seem lost what to do, and only seek assistance after panic kicked in. End of the day, some were not even able to code a simple program with the Zumo responding to the sensor's inputs.

1A21 (Lecturer 1): They are in general playful, and some of them were only willing to try out the activities during the class when asked. Quite a handful of them did not use the tokens as they relied on their peers. However, not all seem to bother to learn when their peer was teaching them. Those who helped their peers became better.

1B02 (Lecturer 1): This class was seen as very motivated and loves challenges. When given a challenge, they were excited to solve it on their own. More than 80% of the students refused to use the token to ask the lecturer any questions while they were preparing for their Zumo competition. Most believed they could solve the problems on their own and did not mind spending the extra time and effort to constantly improving their strategies and test it out with other groups.

1A22(Lecturer 2): This class appeared much happier and during lessons demonstrate a fun attitude. Most students use one or two tokens while preparing for their Zumo. Though most of them did not revise/review their learning regularly, most are ready to demo their coding and test run their project.

1B03(Lecturer 2): Only 30% of students in this appear to be enjoying the module. Others show lots of worry in learning and claim difficulty due to a lack of programming skills. 50% of the class displayed difficulty in catching up and take a much longer time to respond to testing their project and coding. Most of them still expected high dependence from the lecturer.

From the findings, we also gained the following insights that are useful for the next action research:

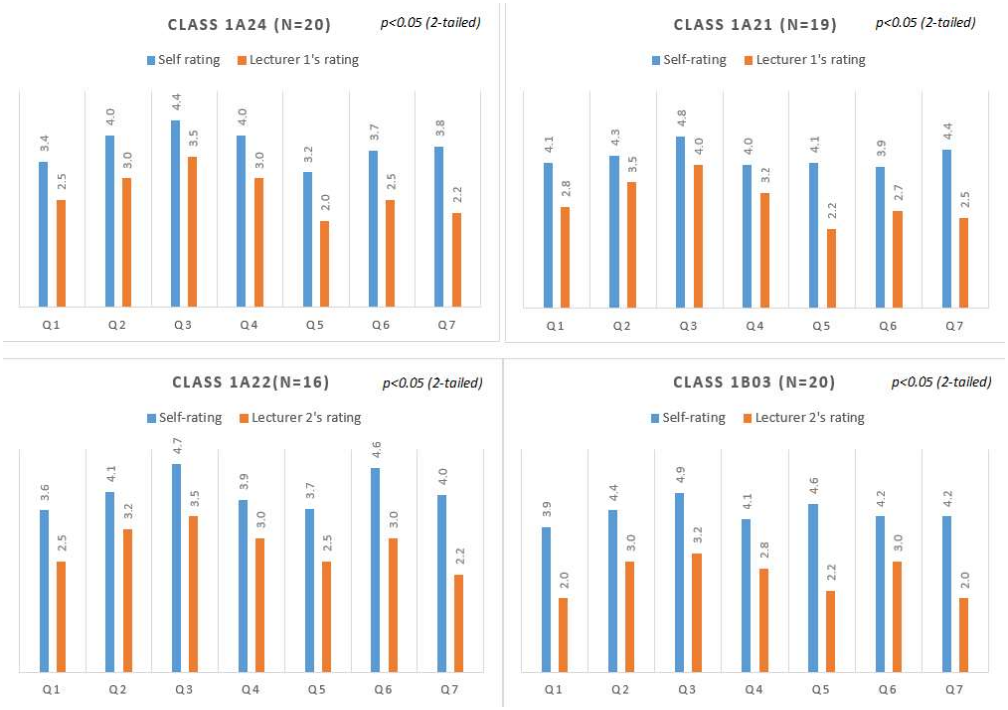


Figure 4. Students rated themselves higher on their SDL behaviour than their lecturers (statistically significant) for class 1A24, 1A21, 1A22 and 1B03

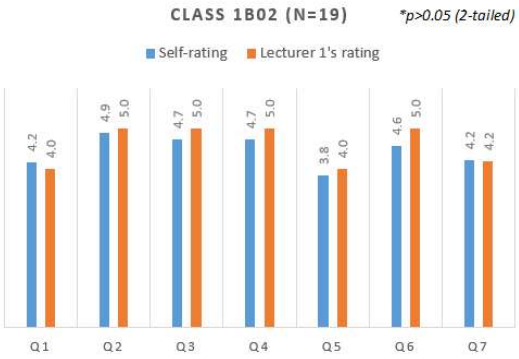


Figure 5. Students from 1B02's rated themselves slighter lower on their SDL behaviour than their lecturer (not statistically significant)

Students Who Enjoyed the Module, But Many Did Not Revise/Review Learning Regularly

In general, the majority of the students enjoyed the module, as they have indicated with a minimum score of 4 in the self-assessment form. However, it was not known if the students from 1A24,1A21,1A22 and 1B03 have a strong growth mindset as there were no obvious classroom observations to support the high score they have given to themselves. When we followed up with the students, some of the students did continue to display strong confidence that they were able to manage their learning. We thus suspected one of the contributing factors was that they were not revising and reviewing regularly.

Students who are seen SDL ready rated themselves lower compared to lecturer's rating of themselves

The student from class 1B02 displayed a strong growth mindset that they can solve their problem. They were observed to have high ownership of their learning and were ready to work more independently. However, as seen in Figure 5, these students ranked themselves lower than what their lecturer will rank them.

Students Who are Seen to Have Low Ownership of Their Learning Rated Themselves Significantly Higher Compared to Lecturer's Rating of Themselves

On the contrary, students who were observed to display having low ownership of their learning rank themselves statistically significantly higher than what their lecturer will rank them. This can be seen in Figure 4. During the 1st half of the module, they were all encouraged to ask as many questions when they are learning something new. However, comments such as "the sensor did not work," and "the Zumo codes does not work properly" were still common during the 2nd half of the module. While the authors attempted to ask questions to get the students further describe the problems, most of them were still expecting direct solutions. This could be due to panic and anxiety, as they did not review their learning regularly and had to do their coding at the very last minute.

Students Displayed Poor Time Management and Were Multitasking

There are many factors for students not taking ownership of their learning. One key factor both authors observed were the students (except for class IB02) did not manage their time well.

They have always seen multitasking during the class and always procrastinate on the given learning tasks (e.g., submitting an assignment late). This results in not having sufficient practice to construct their knowledge before they can work on the codes themselves to prepare for the Zumo competition. When it was time for the students to code on their own, a handful of them suddenly felt panic and anxious as they did not ensure that they have learned prior materials. When asked, many admitted that they did not pay sufficient attention in class and practice sufficiently even though they believe they can manage their learning if they have planned earlier. All these were consistent with students' comments, as seen in Table 2, "poor time management," "read up more," and "ask more questions during the classroom," being the top 3 frequent responses.

Revising Plans for Cycle Two

The strategy to use less direct instruction and more questioning to promote active/independent learning in the classroom was a very helpful approach and will remain in the 2nd cycle. However, through pilot action research, both the authors came to realise that many students did not spend enough time to practice their coding. One of the key factors is students simply do not typically use distributed practice as they work toward mastering course content. When we followed up with the students, we realised that many might unknowingly think they can master the content using massed practice, or they felt they have already mastered the knowledge by understanding what is being delivered to them during the class.

Let the Students Experiment that Knowledge is Constructed and not Transferred

Thus, to encourage the use of the distributed practice, it is important to first let our students understand that knowledge is constructed and not transferred, as quoted by Peter Senge (1990). For this, a simple activity can be designed where students will be asked if they think they have learned the material after what is being taught. It can then be follow-up with a learning task where students need to apply what they have just learned. It is very likely that students who are doing it for the very first time would have some struggles.

Encourage Distributed Practice and not Massed Practice

To further encourage distributed practice, the students need to understand how our brains learn and the benefits of using distributed practice compared to massed practice as Willingham, Daniel. (2002) has shared. However, in the beginning, we foresee that most students forget about what the teaching staff has mentioned. They will only begin to prepare and study only when they are reminded of the coming test or project assignments. By that time, cramming is their only option. To distribute practice over time, we plan to recap important concepts and have weekly or biweekly mini-quizzes before each lesson. On top of this, we plan to get students to come out with their learning plan so that we can help them to map out how many study sessions they will need before the Zumo competition preparation.

Introduce "Pomorodo" Technique during the Class

As students were always multitasking in the classroom, it is difficult for them to be able to focus on learning during the class. To deal with this, we plan to introduce the Pomorodo technique to all the students during the class. Barbara Oakley, who teaches a course on "learning how to learn," says one of the most effective techniques she knows of was created by an Italian named Francesco Cirillo. It's called the Pomodoro Technique. The technique is very simple. It begins with deciding what task to be done. The timer is then set to typically 25 minutes. All the

students were to work on the task by putting their phones away, not browsing the web until the timer rings. After the timer rings, the students can take a short 3 to 5 minutes break to check their handphones and start their timer to work on the task/another task again. However, the authors foresee it may be difficult at the beginning since it is natural for the brain to shift its attention to something else in the first few minutes. Thus, it is very likely that some amount of collective practice over a few weeks are needed for the students to build this useful learning habit.

CONCLUDING THOUGHTS

This paper presents personal experiences with instances of how students rely on us on their learning. These experiences were similar among colleagues, as well. The SP's SDL framework that was established to address this area of concern was presented as well. However, it was perceived by many that it would be overwhelming if one expected to implement all the SDL phases accordingly to the framework. Like many teaching staff, the authors were not sure how to proceed and thus decided to test out some interventions to promote SDL. Through the pilot action research, we discovered some useful insights. One, we find that the self-assessment tool is unlikely to help students with low ownership of their learning to manage their learning process. Two, we find that students have poor time management, did not have sufficient practice before the given project assignment, and were always seen multitasking in the classroom. All these factors seem to greatly hinder the students from being more self-directed. To deal with these issues, learning strategies, including teaching the students the right mindset for the next action research, were planned.

Lastly, we find that it is very challenging to facilitate self-directed learning as it involves scaffolding of the thought processes. After all, many of us were new to teaching and assessing students' cognitive skills. Running these sessions often requires us to devote sufficient time to first understand our students' challenges and be able to recommend strategies that can help them. This means we need to constantly build our knowledge on how the brain learns and builds "how-do coach" skills to help students develop these cognitive skills. All these are enough to make fostering SDL amongst students challenging and overwhelming to many colleagues who are unfamiliar. The use of reflective action research to implement simple SDL inventions at a time is thus appropriate. Such methodology helps us to build our experiences, knowledge, skills, and confidence. We hope this piece of work can also encourage our colleagues to kick start in the way they feel they can manage and come together to share/reflect the practices.

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BIOGRAPHICAL INFORMATION

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