FOSTERING SELF-DIRECTED LEARNING: INSIGHTS FROM INDUSTRY NOW CURRICULUM

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The Education 4.0 taxonomy in the World Economic Forum 2023 report emphasized areas, such as problem-based and collaborative learning, and lifelong and student-driven learning, to guide educators on the evolving needs of the future workforce. At Singapore Polytechnic (SP), Industry Now Curriculum (INC) is a Project-Based Learning (PjBL) curriculum that trains School of Computing (SoC) students to be industry-ready software developers prepared to work and learn at the same time to stay relevant in the industry. This study investigates how INC students engage in self-directed learning (SDL) and how the self-directedness for INC and non-INC students differs. The study found that INC students are significantly higher in Intrinsic Motivation and Metacognitive Self-Regulation & Self-Monitoring compared to non-INC students in the pre-study. The INC students who submit their Learning Journals more frequently tend to have a greater increase in their Metacognitive Self-Regulation & Self-Monitoring skill.

Keywords: *self-directed learning, project-based learning, self-management, self-monitoring, self-regulation, motivation*

Introduction

The Industry Now Curriculum (INC) adopts a "learn by doing" pedagogy to allow students to achieve learning outcomes by doing industry real world project instead of traditional classroom instruction. INC environment emulates a real software development company project structure with continuous operation beyond an academic semester for students to manage projects and learn on an ongoing basis. Moreover, INC encourages students to set personal learning objectives, track their own progress and evaluate how well these objectives were met, encouraging greater responsibility for their own learning.

This research aims to study how INC students engage in self-directed learning (SDL) in various dimensions and how the self-directedness for INC and non-INC students differs in various dimensions. The findings of this study will inform future designs and implementation of SDL developmental activities for students and contribute to improving the active learning experience of project-based learning environments. The following are the research questions:

RQ1: How do INC students engage in self-directed learning?

RQ2: How does the self-directedness for INC and non-INC students differ?

Literature Review

Project-Based Learning

Project-Based Learning (PjBL) is a student-centered, inquiry-based pedagogical approach that engages students in comprehensive projects, often addressing real-world problems. It aims to cultivate concepts, principles, and practical applications. The process typically involves posing essential questions, designing a project plan, scheduling, monitoring progress, assessing outcomes, and evaluating the learning experience. PjBL fosters active learning, critical thinking, problem-solving, communication, and collaboration through hands-on activities, making it effective for developing crucial 21st-century skills necessary for the job market. It provides practical experience, deeper understanding, and increased motivation by connecting learning to real-life situations and industry needs (Agustina et al., 2022; AlAli, 2024; Asnur et al., 2025; Bahrehvar & Moshirpour, 2022; Masnec et al., 2024; Morrison et al., 2021; Saad, 2022).

Määttä et al (2017) proposed a project-based learning environment called the FIRMA that distinguishes itself from common PjBL by emulating a real software company structure and deeply integrating industry collaboration. The FIRMA operates year-round, not adhering to traditional academic year schedules, which reflects the continuous nature of a real business and requires students to manage projects and learn on an ongoing basis. Students set personal learning objectives, track their working hours, and evaluate how well these objectives were met, encouraging greater responsibility for their own learning. Students can complete a significant portion of their degree within the FIRMA, integrating their project work directly into their curriculum for credits and grades. INC was adapted from this FIRMA approach.

Self-Directed Learning

Garrison (1997) proposed a comprehensive model of Self-Directed Learning (SDL) that includes three overlapping dimensions: Self-Management, Self-Monitoring, Motivation.

At SP, the SDL model expands on these dimensions needed for a self-directed learner. The following are five sub-dimensions in this model:

1. Self-Efficacy for Learning & Performance
   Self-efficacy for learning and performance is a belief in one's capability to succeed in a specific task (Morris, 2019; Pintrich & De Groot, 1990; Bandura, 1982).
2. Growth Mindset
   Growth Mindset, specifically the belief that intelligence and personality are malleable and can change, is identified as a dimension for SDL (Brandt, 2020; Dweck, 2006).
3. Intrinsic Motivation
   Intrinsic motivation, as a dimension of SDL, refers to developing and sustaining motivation for learning (Ryan & Deci, 2020; Brandt, 2020; Garrison, 1997; Pintrich & De Groot, 1990).
4. Help Seeking
   Help seeking is a resource management strategy in learning (Pintrich & De Groot, 1990). Collaboration is intricately related to self-directed learning, and learners develop SDL skills as they engage with others (Brandt, 2020; Gibbons, 2002).
5. Metacognitive Self-Regulation & Self-Monitoring
   There are three general processes in metacognitive self-regulatory activities: planning, monitoring, and regulating (Brandt, 2020; Pintrich, 2004). Planning (e.g., goal setting, task analysis) helps activate prior knowledge. Monitoring (e.g., tracking attention, self-testing) helps understanding and integration with prior knowledge. Regulating involves fine-tuning and adjusting cognitive activities to improve performance by checking and correcting behavior. Self-monitoring involves being aware of the current state of knowledge, searching for information, exploring concepts, confirming knowledge, and assessing outcomes (Zhu & Bonk, 2019; Garrison, 1997).

Robinson & Persky (2020) reported that assessing SDL skills can be challenging because many domains are affective in nature (e.g., problem-solving, collaboration, self-awareness) especially in a PjBL setting, such as INC. Nevertheless, this study will address this gap by investigating how the SDL skills are developed in INC students and compare with non-INC students.

Methodology

INC Pathway Student Recruitment

The recruitment and selection process for students entering the INC pathway is a multi-stage process designed to identify individuals with the necessary technical aptitude, problem-solving skills, and personal attributes to thrive in an industry-focused learning environment. Here's a breakdown of the recruitment and selection process:

Briefing and Initial Registration

The process begins with a briefing for all Year 1 students during Semester 2. This briefing provides an overview of the Project INC pathway, explaining the benefits of the programme such as building relevant portfolio through working on real-life industry projects. Following the briefing, students register their interest through an online Microsoft Form with some of the following information:

- Their passion for Computer Science domain, including descriptions of any favorite work.
- Their thoughts on the characteristics/attributes of a reliable independent learner.
- Their passion for teaching and sharing, and the reasons why.
- A list of their current Co-Curricular Activities (CCAs) or clubs (inside or outside of SP), including their role and capacity.

Gathering Inputs Before Interview

Before the interview stage, additional information is gathered to provide a holistic view of the student's suitability for the INC pathway. This includes:

- Mid-Semester Test results from a Year 1 core module. This module is specifically chosen as a significant reference to assess if a student's learning disposition aligns with that of an INC student, indicating qualities such as being an self-directed learner and good time management. Historically, students who performed well in that Year 1 module have generally been observed to perform well in the INC pathway.
- Feedback from Personal Tutors of the registered students. Tutors provide insights into the student's attitude and character and whether the student is a potential matured team leader.

Interview Process

Students who have registered and provided the necessary input are scheduled for an interview. The interview is conducted by a panel of INC Lecturers who take turns asking questions across specific categories. A score is assigned to each student in the following categories: Technical Skills, Problem-Solving Abilities, Collaboration and Teamwork, Adaptability and Learning Agility, Interest and Passion for Coding, Future Aspirations and Career Goals, Communication Skills.

Scoring and Final Selection

After all interviews are completed, the scores given by the interviewers for each student are consolidated and ranked. The final selection of students for the INC pathway is based on the ranking of their scores.

Continuous Integration and Continuous Delivery (CICD) module

The CICD module is designed as a capstone module to provide them with the opportunity to consolidate prior learning and learn concepts of the industry practice of Continuous Integration and Continuous Delivery

(CI/CD) to develop an application within a team. Throughout the module, students actively develop and operate an application in groups. They manage code repositories, set up automated build pipelines, perform continuous testing, and deploy changes to production environments. By experiencing the entire CI/CD workflow, students acquire practical skills and a deep understanding of how to streamline software delivery and enhance collaboration within a development team. The learning outcomes for the module are the same for INC and non-INC students.

Non-INC Pathway

The non-INC participants include 9 classes of 204 students working on a module project. All lesson materials are released and delivered via the Learning Management System (LMS) weekly, and students are expected to go through and learn the materials before the two onsite practical classes. During practical classes, there would be instructor teaching and learning activities that allow students to collaboratively learn, discuss, and explore on the new lessons and challenges faced. Throughout the semester, students would work on the module project which the student has autonomy to choose the theme and the scope to work on.

INC pathway

The INC participants include 2 classes of 28 students working on a real-world project with an external client. The INC students can consult their tutor throughout the semester for advice whenever necessary. There is no instructor-led teaching during class. Students discover much of what they learn through the prescribed e-learning content in the LMS and through the process of applying their knowledge in the client project. The students do not have autonomy to choose the project theme and scope as the project belongs to the external client. The INC students are expected to record and submit their self-management and self-monitoring every 2 weeks through Learning Journals in the LMS. The information recorded in the Learning Journal are:

- Planning – Targeted Learning Outcomes, Learning Resources & Strategies and Evidence of Accomplishments
- Monitoring and Review – Progress, Problems / Challenges, Plans Ahead

SDL Survey and Focus Group Discussion

An SDL survey, adapted from Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & De Groot, 1990; Roth et al, 2016) was conducted using Microsoft Forms on week 2-3 (pre) and week 17-18 (post) to measure the self-directedness of the INC and non-INC students taking CICD module in the following sub-dimensions:

- Self-Efficacy for Learning & Performance (SE)
- Growth Mindset (GM)
- Intrinsic Motivation (IM)
- Help Seeking (HS)
- Metacognitive Self-Regulation & Self-Monitoring (MRM)

Focus group discussion was conducted with separate sessions of 8 INC students and 8 non-INC students to collect qualitative inputs to add insights to the survey data. Academic performance and LMS data were also used to study the effects of the strategy.

Results

Table 1 shows the number of non-INC and INC students who participated in the pre- and post-study SDL survey.

Table 1
The number of students who completed the pre- and post-study survey

Group	Pre/Post	Number of Students
Non-INC	Pre	145
	Post	133
INC	Pre	26
	Post	27

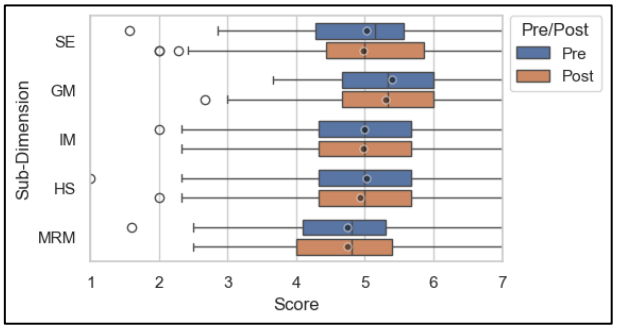

Figure 1. Non-INC students' pre- and post- survey boxplots

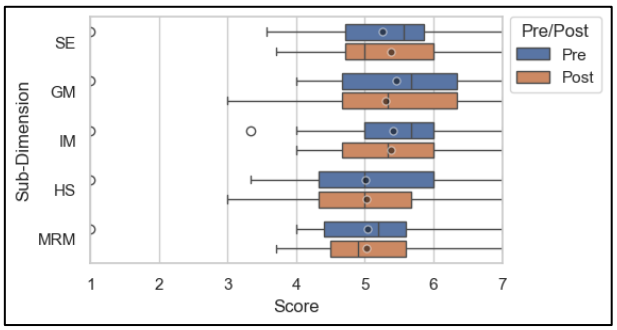

Figure 2. INC students' pre- and post- survey boxplots

A Wilcoxon Signed Rank test was conducted to compare the pre- and post-study survey data for both non-INC (Figure 1) and INC students (Figure 2). There is no significant difference ($p > 0.05$) for each SDL sub-dimension between the pre- and post-study score for both non-INC and INC students.

A Mann-Whitney U test was conducted for pre-study SDL survey score for each sub-dimension between non-INC and INC students (Table 2). There is significant differences ($p<0.05$) between Intrinsic Motivation ($U=834$, $p=0.016$) and Metacognitive Self-Regulation & Self-Monitoring ($U=900$, $p=0.048$) sub-dimensions. Figure 3 shows the boxplots comparing the pre-study

scores for non-INC and INC students. INC students are generally rated higher in median in all SDL sub-dimensions for the pre-study SDL survey compared to non-INC students, except Help-Seeking, with significant difference in Intrinsic Motivation and Metacognitive Self-Regulation & Self-Monitoring.

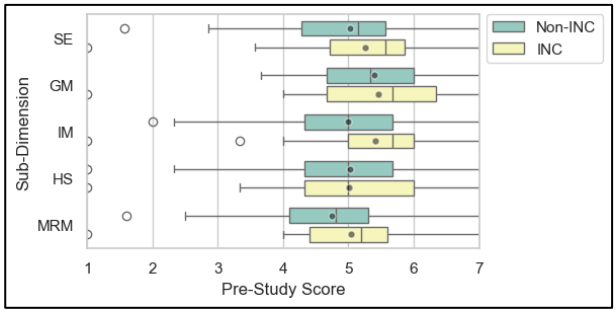

Figure 3. Pre-study survey boxplots for non-INC and INC students

Table 2
Mann-Whitney U test for pre-study survey score between non-INC and INC students

Sub-dimension	N (non-INC)	N (INC)	U	p
Self-Efficacy for Learning & Performance	97	25	962	.112
Growth Mindset	97	25	1072	.372
Intrinsic Motivation	97	25	834	**.016***
Help Seeking	97	25	1171	.791
Metacognitive Self-Regulation & Self-Monitoring	97	25	900	**.048***

As INC students are expected to submit Learning Journals in the LMS, the number of submissions in the dropbox was collated for each student. A Spearman's rank-order correlation revealed a weak to moderate, positive, and statistically significant association between the INC LMS dropbox count and the difference between pre- and post-study SDL score for Metacognitive Self-Regulation & Self-Monitoring, rs(23)=0.397, p=0.05 (Table 3).

Table 3
Correlation between INC LMS dropbox count and the difference between pre- and post-study SDL score, N=25

Sub-dimension	Spearman rs	p
Self-Efficacy for Learning & Performance	.069	.744
Growth Mindset	.187	.371
Intrinsic Motivation	-.163	.437
Help Seeking	.127	.544
Metacognitive Self-Regulation & Self-Monitoring	.397	**.050***

As the Learning Journals are assessed in Assignment 4, a Pearson correlation (Table 4) revealed a moderate, positive, and statistically significant association between Assignment 4 grades and the difference between pre- and post-study SDL score for Metacognitive Self-Regulation & Self-Monitoring, r(23)=0.406, p=0.044.

Table 4
Correlation between Assignment 4 grades and the difference between pre- and post-study SDL score, N=25

Sub-dimension	Pearson r	p
Self-Efficacy for Learning & Performance	.164	.433
Growth Mindset	.219	.292
Intrinsic Motivation	-.089	.671
Help Seeking	.224	.282
Metacognitive Self-Regulation & Self-Monitoring	.406	**.044***

Discussion

RQ1: How do INC students engage in self-directed learning?

Table 3 shows a weak to moderate, positive, and statistically significant association between the INC LMS dropbox count and the difference between pre- and post-study SDL score for Metacognitive Self-Regulation & Self-Monitoring, rs(23)=0.397, p=0.05. The students who submit their Learning Journals more frequently tends to have a greater increase in their Metacognitive Self-Regulation & Self-Monitoring skill. This also positively and moderately correlated with better grades in Assignment 4 (Table 4). The Learning Journal require the students to set their learning goals, define the self-evaluation criteria, plan activities, monitor progress, list challenges faced, and review plans (Gibbons, 2002). With more practice in writing and submitting the Learning Journal, it will improve Metacognitive Self-Regulation & Self-Monitoring skill.

In the focus group discussion, INC students acknowledged the Learning Journal's value in helping them reflect on their learning journey, track progress, and identify areas for improvement (Gibbons, 2002). One student commented, "I just, like, put down what I have done for that week… it makes me realise that, oh, this week I didn't complete as much."

However, there is no significant difference ($p > 0.05$) for each SDL sub-dimension between the pre- and post-study score for INC students in this study. Interestingly, there is a decrease in the median score of all SDL sub-dimensions, except Help-Seeking, between pre- and post-study for INC students, though it is not statistically significant (Figure 2).

Many INC students expressed confusion about what to write in the Learning Journal. They were unsure whether to focus on technical content, personal reflections, or challenges faced. The lack of clarity in column headings and expectations led to inconsistent entries. INC Students also found that daily entries are impractical, citing difficulty recalling specific activities and a lack of motivation to write regularly. Several

students also mentioned using AI tools like ChatGPT to draft or expand their journal entries. A recurring theme was that students often completed journals out of obligation rather than intrinsic motivation. Deadlines were the primary driver, and some admitted to backfilling entries just before submission. The above sentiments may have resulted in a mixed perceived value of the Learning Journal in the students' own learning process. Määttä et al (2017) also reported about challenges faced by students when using a learning diary each month and replaced it by letting students defining the learning objectives at the beginning of the project and evaluating how well they were met at the project's completion. However, from the earlier results, the reduction of the Metacognitive Self-Regulation & Self-Monitoring activities may not help the students to develop it.

The tutors shared that it took a few rounds of tutor feedback to the students before the students are clearer on what to write in the Learning Journal and the good practices, despite the students being briefed and given examples in the template. The tutors also shared that it was time-consuming to go through all the submitted journals and challenging to give timely feedback for each journal. This may have resulted in the students' lower motivation of submitting the Learning Journal too.

INC students shared that their engagement in SDL is strongly influenced by personal interest. When topics resonate, they are more likely to invest time in research and experimentation (Ryan & Deci, 2020; Morris, 2019). One commented, "If the topic is something I don't find interesting… I don't think I will try to search more about it." Conversely, lack of interest leads to minimal effort. Another commented, "Whether I put in extra effort depends on whether I'm interested in that module." The lack of student autonomy or choice in the INC students' project may have reduced their Intrinsic Motivation and affected their engagement in SDL in general, which may explain the drop in median rating in Figure 2.

RQ2: How does the self-directedness for INC and non-INC students differ?

From Table 2 and Figure 3, INC students are generally rated higher in median in all SDL sub-dimensions for the pre-study SDL survey compared to non-INC students, except Help-Seeking, with significant difference in Intrinsic Motivation ($U=834$, $p=0.016$) and Metacognitive Self-Regulation & Self-Monitoring ($U=900$, $p=0.048$). As described earlier for the INC recruitment process, the INC students took the active steps to describe areas related to SDL in their application such as their passion, their thoughts on the characteristics/attributes of a reliable independent learner and their passion for teaching and sharing. Moreover, they are being interviewed and assessed with SDL-related criteria such as Collaboration and Teamwork, Adaptability and Learning Agility, and Interest and Passion for Coding. Hence, it is not surprising that there is a higher pre-study SDL rating of INC students, especially Intrinsic Motivation and Metacognitive Self-Regulation & Self-Monitoring.

From the focus group discussion, both INC and non-INC students are motivated by grades and deadlines, but INC students mentioned that their motivation is also tied to personal interest and growth. Ryan and Deci (2020) suggest that traditional grades often undermine students' intrinsic motivation. Resourcefulness is mentioned as a crucial SDL attribute for INC students in contrast to non-INC students as the students research beyond provided materials which can be due to the needs of real-world projects (Brandt, 2020; Knowles, 1975). Both non-INC and INC Students shared that SDL is most effective when working on projects. They learn by doing, iterating, and solving problems, often discovering gaps in their knowledge through hands-on experience. One non-INC student commented, "Only when I'm doing my project… then I go back to read.". Similarly, one INC student commented on such learning gap in a real-world project, "We skipped the design step… changing the database was very painful."

The tutors gave the feedback that time management is the recurring theme for both INC and non-INC groups influencing the students' success (Pintrich & De Groot, 1990). Students who planned tasks weekly and maintained individual to-do lists were more likely to meet project deliverables. Conversely, those who procrastinated or underestimated task complexity tended to fall behind. The bi-weekly submission of the Learning Journal provides INC tutors with an indication of how well the INC students are growing in their Metacognitive Self-Regulation & Self-Monitoring skill (Table 3).

Limitations

A limitation of this study is the relatively small sample size of INC students, which may restrict the generalizability of our findings. It might be possible that some changes might have occurred but were not statistically significant due to the limited sample size. Moreover, the SDL skills of the students may be affected by other factors, such as concurrent modules or personal life.

Future Studies

Future research could include more batches of students to expand the sample size of INC students. The Learning Journal could be improved by providing better guiding questions and example statements to reduce the confusion the students faced when using it and encourage more frequent use to develop the Metacognitive Self-Regulation & Self-Monitoring skill. Generative AI technology can be explored to enhance the use of the Learning Journals by the students and to provide timely feedback by tutors. Future studies can also explore various Intrinsic Motivation strategies to help INC students be motivated to learn (Ryan and Deci, 2020) and research how Help-Seeking skill can be developed.

Conclusions

Our findings do not indicate significant differences for each SDL sub-dimension between the pre- and post-study score for INC students. However, the INC students

who submit their Learning Journals more frequently tend to have a greater increase in their Metacognitive Self-Regulation & Self-Monitoring skill. There is a mixed perceived value of the Learning Journal in the students' own learning process and the lack of Intrinsic Motivation may have affected the desired development of the Metacognitive Self-Regulation & Self-Monitoring skill for the INC students. Hence, the Learning Journal can be improved for more intuitive use to help students build SDL skill.

INC students are generally rated higher in all SDL sub-dimensions for the pre-study SDL survey compared to non-INC students, except Help-Seeking, with significant difference in Intrinsic Motivation and Metacognitive Self-Regulation & Self-Monitoring. The recruitment process may have selected those students with higher SDL skills to enter the INC pathway. Both groups are motivated by grades and deadlines and agreed that project work helps them develop SDL skills. However, the INC students reported that they are also motivated by personal interest and growth. Time management is a key factor observed by tutors of both groups for academic success and the Learning Journal provided a regular structure for INC students to plan, monitor and review their learning and for tutors to track their progress.

References

Agustina, W., Degeng, I. N. S., Praherdhiono, H., & Lestari, S. R. (2022). The effect of blended project-based learning for enhancing student's scientific literacy skills: An experimental study in University. *Pegem Journal of Education and Instruction*, 13(1), 223-233.

AlAli, R. (2024). Enhancing 21st century skills through integrated STEM education using project-oriented problem-based learning. *Geo Journal of Tourism and Geosites*, 53(2), 421-430.

Asnur, L., Jalinus, N., Faridah, A., Irfan, D., Mubai, A., & Utami, F. (2025). Empowering Project-Based Learning Model With Video Blog. *TEM Journal*, 14(1).

Bahrehvar, M., & Moshirpour, M. (2022). Full-stack development and soft skills: An agile-based learning framework. *Proceedings of the Canadian Engineering Education Association (CEEA)*.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist*, 37(2), 122.

Brandt, W. C. (2020). Measuring Student Success Skills: A Review of the Literature on Self-Directed Learning. 21st Century Success Skills. National Center for the Improvement of Educational Assessment.

Dweck, C. S. (2006). *Mindset: The new psychology of success.* Random house.

Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult education quarterly*, 48(1), 18-33.

Gibbons, M. (2002). *The self-directed learning handbook: Challenging adolescent students to excel*. John Wiley & Sons.

Knowles, M. S. (1975). *Self-directed learning: A guide for learners and teachers*.

Määttä, S., Roslöf, J., & Säisä, M. (2017). Development of the learning process in a project-based learning environment. In *Proceedings of the 13th International CDIO Conference* (pp. 270-278).

Masnec, L., Stapić, Z., & Benkus, M. (2024). Bridging Academia and Industry: A Collaborative Approach to Software Development Education. In *35th International Scientific Conference CECIIS 2024* (pp. 433-440). Varaždin: University of Zagreb, Faculty of Organization and Informatics.

Morris, T. H. (2019). Self-directed learning: A fundamental competence in a rapidly changing world. *International Review of Education*, 65(4), 633-653.

Morrison, J., Frost, J., Gotch, C., McDuffie, A. R., Austin, B., & French, B. (2021). Teachers' role in students' learning at a project-based STEM high school: Implications for teacher education. *International Journal of Science and Mathematics Education*, 19, 1103-1123.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational psychology review*, 16, 385-407.

Pintrich, P.R. & De Groot, E.V. (1990) Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33-40.

Robinson, J. D., & Persky, A. M. (2020). Developing self-directed learners. *American journal of pharmaceutical education*, 84(3), 847512.

Roth, A., Ogrin, S., Schmitz, B. (2016) Assessing self-regulated learning in higher education: a systematic literature review of self-report instruments. *Educational Assessment, Evaluation and Accountability*, 28, 225–250.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary educational psychology*, 61, 101860.

Saad, A. (2022). The effectiveness of project based learning with computational thinking techniques in a software engineering project course. *Journal of Contemporary Issues and Thought*, 12(1), 65-79.

Zhu, M., & Bonk, C. J. (2019). Designing MOOCs to facilitate participant self-monitoring for self-directed learning. *Online Learning*, 23(4), 106-134.