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Design-Based Learning Activity and Self-Regulation in Education: A Review

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Abstract

Design-based learning has been widely recognized for its impact on the cognitive domain within educational settings. However, limited research has explored the interaction between design processes and students' self-regulation. This paper reviews 15 relevant studies to investigate the relationship between these two constructs. Findings suggest that design-based learning which implemented through activities, projects, or problem-based tasks to fosters a complex, dynamic, and mutually reinforcing relationship with self-regulation. This interaction appears particularly robust in both science-oriented and art-related educational contexts. The review highlights overlapping cognitive and metacognitive elements that may influence this relationship. Further empirical research is needed to examine how self-regulation and design processes operate in practical pedagogical environments.

Keywords: Design-Based Learning, Self-Regulation, Metacognition

1. Introduction

Design is a word that we may heard every day. The term of design may refer to something that people do every day unconsciously, but there is also "Design" that elaborate a complex process that elaborate explicit stages. The different between their degrees of formalization: while everyday design is often spontaneous or even intuitive, with the designer unaware that she is engaged in a problem-solving process that coul perhaps be improved upon (Fortus et al., 2004). "Design" as a formal process may include many explicit criteria for determining whether the outcomes of the design process are acceptable. Everyday designers often conduct abrupt error in their decisions and considerations; the formal Design process attempts to minimize the chances that Designers will do so as well (Fortus et al., 2005).

Within this paper, the underlined concept of the design-based learning is any activities in learning that uses the design as the vehicle. Moreover, the design-based learning also related to activities that involving goal of creating an artifact or end product (Fortus, 2005). There are various instructional model or strategy as integration of this concept of "Design" in educational research and practice, such as; science project to solve local problem (Reyna et al., 2019; Tas et al., 2019), STEM learning (Li, Chen, et al., 2020; Li, Du, et al., 2020; Zheng et al., 2019; Zheng, Xing, Zhu, et al., 2020), engineering project (Goldstein et al., 2019), visual media (Kurt & Kurt, 2017; Mou, 2020b, 2020a), programming design (Lin & Tsai, 2016), etc. Design as an iterative process can promote metacognition self-regulation of students (Lin & Tsai, 2016; Michel et al., 2017; Tas et al., 2019). While the other studies found a lot more diverse findings about Design-Based Learning other than promoting self-regulation mainly based on two distinct learning environment, which is computer-aided environment (Goldstein et al., 2019; Li, Chen, et al., 2020; Li, Du, et al., 2020; Mou, 2020b, 2020a; Reyna et al., 2019; Splichal et al., 2018; Zheng et al., 2019; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), and without computer-aided environment (Kurt & Kurt, 2017; Tas et al., 2019).

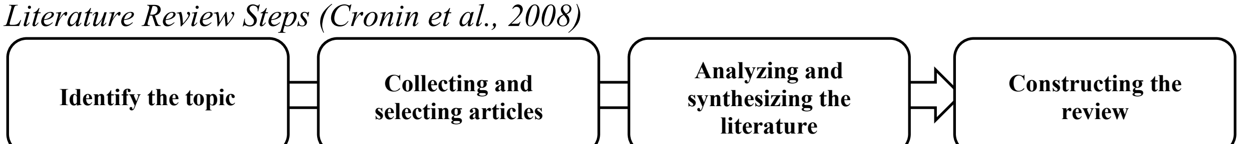
The interesting part of the interrelated design iterative processes and self-regulation that they are interconnected to each other. For example, some studies found that the design process affect the students' self-regulation (Tas et al., 2019; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), while there are also findings stated that self-regulation affect the design process and learning outcome (Li, Chen, et al., 2020; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020). Moreover, other studies found that design capacity and prior knowledge can mediate the learning knowledge (Zheng, Xing, Huang, et al., 2020). Surprisingly, students' self-regulation also augmented in a very malleable and dynamic process (Li, Du, et al., 2020; Zheng et al., 2019), and it can affect other students' self-regulation (Lin, 2018; Splichal et al., 2018). Furthermore, other than in science disciplinary, design process (such as designing visual media) regardless of content also showing relation to self-regulation (Kurt & Kurt, 2017; Mou, 2020a, 2020b). Within this context, this paper will explore the interconnected findings of learning that involving design-based activity or project in regard to students' self-regulation and vice versa. The purpose of this study was to explore the relation and connection between design-based learning activity or project and students' self-recognition in various research context which is aimed in science and also broader educational settings. The question that guides this study is "how is the relationship/connection established between design-based activity or project and students' self-regulation?"

2. Methods

This paper using literature review or content analysis method. This review includes the research articles that using design iterative processes and self-regulation in the variables. Based on design iterative process term, it can be mean to be a broader scope as explained in the introduction, thus, it may relate to any other syntax of learning/teaching method that contain the overlapping syntax with the design iterative process. To find the primary articles, online articles database such as ERIC, Google Scholar, Science Direct, Springer, etc. was used to find the corresponding articles. The criteria of sources used in this paper are the articles was published as early as 2016 and was published in the journal that indexed Q1 or Q2 in the ScimagoJr. The flowchart and fundamental steps of the method in this paper showed in Figure 1.

Figure 1.

Literature Review Steps (Cronin et al., 2008)



The steps of the study is further described as follows:

1. Identifying the topic step in this paper consist of identifying the variable, determining the keywords and its alternatives, and limitations or criteria of sources that will be used in the study. Because of the peculiar case and question of the research, the keywords indeed changing vastly and the exploration of the articles takes about three months to search and select the appropriate articles for this study.
2. Collecting and selecting articles step done by doing a vast search on the online journal articles database such as ERIC, Google Scholar, and Science Direct with the criteria that it was published as early as 2016 and latest to 2020 to gather the five-year interval study. The papers should be indexed Q1 or Q2 in ScimagoJr. Throughout the study, the source that mainly used is ERIC and Google Scholar, mainly because every article that indexed in the rank will be come up in Google Scholar while ERIC providing the largest sources for educational research reports, while the author doesn't have access to the Scopus premium search function. To optimize the result of the search, we used advanced search such as using the Boolean operator, time filter, search in title/abstract, using the apostrophe symbol, etc. The search query was optimized by search in title option: "Design" AND "Self-Regulation" OR "Self-Regulated Learning", and other words pattern such as "Design-Based", "Education", "Learning", and so on. The results then checked manually to see the quality of journal, then read the content to make sure that it is in line with the study. This type of semi-manual search extends the depth of the research papers that included into the study.
3. Analyzing and synthesizing done by doing summarizing each of the articles and synthesizing the findings and discussions. This result of this step is presented on Table 1 as the articles included in the study.
4. Constructing the review made based on the outline created on the synthesized findings and discussions of the sources.

The articles included in this study are presented in Table 1.

Table 1.
Articles that included into the study

No	Author	Year - Index	Content Area	Design Elements	Educational Level
1	(Tas et al., 2019)	2019 – Q1	Physics	Design Based Science - Drawing and designing electricity circuit	Secondary
2	(Li, Chen, et al., 2020)	2020 – Q1	Science/Physics	STEM – Energy3D project	Secondary

No	Author	Year - Index	Content Area	Design Elements	Educational Level
3	(Zheng, Xing, Huang, et al., 2020)	2020 – Q1	Science/Physics	Engineering Project – Energy3D project	Secondary
4	(Goldstein et al., 2019)	2019 – Q1	Science/Physics	Solar Urban Design Challenge – Energy3D project	Secondary
5	(Zheng, Xing, Zhu, et al., 2020)	2020 – Q1	Science/Physics	STEM – Energy3D project	Secondary
6	(Li, Du, et al., 2020)	2020 – Q1	Science/Physics	STEM – Energy3D project	Secondary
7	(Lin, 2018)	2018 – Q1	Information and Technology	PBL – Microsoft Access Project	Higher
8	(Michel et al., 2017)	2017 – Q2	Unrelated to specific content	PBL - DDART	Higher
9	(Zheng et al., 2019)	2019 – Q1	Physics	STEM – Computer simulation software	Junior College and Higher Education
10	(Lin & Tsai, 2016)	2016 – Q1	Information and Technology	PjBL – Microsoft access project	Higher
11	(Kurt & Kurt, 2017)	2017 – Q1	Multimedia Design	Design Project	Higher
12	(Mou, 2020a)	2020 – Q1	Multimedia Design	PBL – 3D design project	Higher
13	(Mou, 2020b)	2020 – Q2	Multimedia Design	PBL – 3D design project	Higher
14	(Reyna et al., 2019)	2019 – Q1	Science	Digital Multimedia Project	Higher
15	(Splichal et al., 2018)	2018 – Q1	Science	PjBL – Poster Fair	Higher

Table 1 summarizes a collection of high-quality journal articles (Q1 and Q2 indexed) that explore various implementations of project-based learning (PBL), design-based science (DBS), and STEM-oriented instructional approaches across different content areas. These studies notably focus on the integration of technology and engineering design in science and multimedia education, utilizing tools such as Energy3D, Microsoft Access, and digital multimedia projects. The majority target secondary and higher education levels, indicating a strong trend toward embedding real-world, design-focused learning experiences in advanced educational contexts. A more detailed review of these studies, including their contributions, patterns, and implications that will be provided in the next section.

3. Result and Discussion

To comprehensively capture the core findings from the reviewed literature, a synthesis was conducted to extract recurring themes related to Design-Based Learning (DBL) and its relationship with students' self-regulation (SRL). The synthesis focused on categorizing patterns of impact, learning contexts, and behavioral outcomes. Table 2 presents a thematic summary that organizes the reviewed studies into major themes, subthemes, key insights, and representative sources.

Table 2.
Emerging Themes and Insights

Main Theme	Subtheme	Key Points	Example Studies
DBL enhances students' self-regulation	DBL promotes metacognitive SRL across varied formats	DBL improves SRL through PjBL, STEM, and visual design.	Kurt & Kurt (2017); Tas et al. (2019); Mou (2020a)
	Increased awareness of self-regulation through DBL tasks	Students become more aware of metacognition during DBL.	Michel et al. (2017); Splichal et al. (2018); Lin (2018)
	Iterative design tasks support regulation strategies	Design iteration nurtures monitoring and regulation.	Goldstein et al. (2019); Mou (2020b); Li, Du, et al. (2020)
	Design challenges provoke SRL use	Problem-solving contexts trigger strategy use.	Reyna et al. (2019); Zheng et al. (2019)
Design capacity magnifies science learning outcome	Higher design ability improves science learning outcomes	Design skills and prior knowledge correlate with learning gains.	Zheng, Xing, Huang, et al. (2020); Reyna et al. (2019)
SRL affects learning process and outcome	High SRL learners outperform in science and design tasks	Better regulation predicts higher performance and outcomes.	Li, Chen, et al. (2020); Mou (2020a); Tas et al. (2019)
	SRL supports student engagement and collaboration	SRL fosters time use, contributions, and teamwork.	Lin & Tsai (2016); Mou (2020a); Reyna et al. (2019)

Main Theme	Subtheme	Key Points	Example Studies
	High SRL leads to greater reflectivity and self-efficacy	Reflection and confidence linked with strong SRL.	Goldstein et al. (2019); Mou (2020b); Zheng et al. (2020)
SRL is malleable and dynamic	Students demonstrate flexible SRL strategies	SRL behaviors adjust dynamically during learning.	Li, Chen, et al. (2020); Splichal et al. (2018)
	SRL strategies evolve with task progression	Strategies like planning, help-seeking evolve through task.	Reyna et al. (2019); Splichal et al. (2018)
	Design tasks reveal individual SRL behavior patterns	Patterns in SRL reveal cognitive regulation processes.	Zheng et al. (2019); Lin & Tsai (2016)
Socially-shared SRL in collaborative DBL	STEM collaborative settings foster SRL sharing	Peer SRL levels influence individual development.	Zheng et al. (2019); Li, Du, et al. (2020)
	Group awareness enhances shared SRL development	Structured peer interactions reinforce mutual SRL.	Lin (2018); Reyna et al. (2019)

The themes summarized in Table 2 serve as an overview of the recurring patterns found in the reviewed studies. While the table captures the breadth of findings across diverse contexts, the following sections provide a more in-depth exploration of each theme. These detailed descriptions delve into how Design-Based Learning environments interact with students' self-regulation processes, the role of iterative tasks, the influence of design challenges, and the dynamic nature of both individual and socially shared regulation. Through this elaboration, the nuances and interconnections among the studies are critically examined to uncover deeper pedagogical implications.

3.1. Design-Based Learning environment enhances students' self-regulation

There are a lot studies investigating the effect of some Design-Based Learning environment with related terms such as implemented in; Project-Based Learning (Lin & Tsai, 2016; Mou, 2020a, 2020b; Splichal et al., 2018), STEM learning (Goldstein et al., 2019; Li, Chen, et al., 2020; Li, Du, et al., 2020; Zheng et al., 2019; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), Design-Based Science (Tas et al., 2019). The Design-Based Learning environment implemented to enhance the (assessed) self-regulation (Kurt & Kurt, 2017; Splichal et al., 2018; Tas et al., 2019; Zheng, Xing, Zhu, et al., 2020), or even enhancing their strategy to implement their self-regulation into practice (Kurt & Kurt, 2017; Mou, 2020a, 2020b; Splichal et al., 2018; Tas et al., 2019). Many studies investigated in this paper are involving the computer software in the process, such as Energy 3D (Goldstein et al., 2019; Li, Chen, et al., 2020; Li, Du, et al., 2020; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), Circuit maker (Zheng et al., 2019), Microsoft Access (Lin, 2018; Lin & Tsai, 2016), DDART (Michel et al., 2017), etc. While there are only a few studies investigated in this paper that implement the design learning environment without any aid of computer software (Kurt & Kurt, 2017; Tas et al., 2019). According to these findings, it is showed that the setting of with or without the aid of computer-mediated environment, Design-Based Learning environment may always cause positive result to students' awareness of their self-regulation. Nevertheless, there were not enough information to decide whether one is the best setting to magnify the self-regulation of the students and the learning outcome desired.

3.1.1. Design-Based Project learning environment increases the students' awareness of their self-regulation

There is a positive impact to the students' self-regulation, in term of their awareness to their (perceived) metacognition during a design activity in learning (Kurt & Kurt, 2017; Lin, 2018; Michel et al., 2017; Mou, 2020b; Splichal et al., 2018; Tas et al., 2019). By a study conducted by Tas et al. (2019), design-based science learning strategy found to increase the students' awareness to their self-regulation so that students know their capacity in learning, and their capacity in improving themselves in learning. What makes awareness different than the students' self-regulation (as profile) is that the awareness is perceived subjectively that it may be different than what assessed by the standardized instrument (Mou, 2020a). Zheng, Xing, Zhu, et al. (2020) assured that computer mediated environment in STEM learning support the students' self-awareness thus supporting their self-regulation. The finding also supported by Splichal et al. (2018) who stated that collaborative computer-mediated learning environment could support and facilitate students' self-regulation and its improvement in learning. In doing design activity, students use their metacognition into learning process which made them become more intensely involved in using self-regulation skills like controlling and monitoring their cognition, promoting students' metacognition self-regulation skills and strategies (Kurt & Kurt, 2017).

3.1.2. Iterative design process in a project task/assignment eliciting learners' self-regulation

Iterative design process proven to subsequently promote students' metacognitive self-regulation regarding to the three main aspects of controlling, monitoring and learning regulation (Tas et al., 2019). There are various ways of how studies integrate the design iterative process into learning such as; designing a green energy house to solve science energy problem (Goldstein et al., 2019; Li, Chen, et al., 2020; Li, Du, et al., 2020; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), using computer software to designing best circuit problem about series and parallel (Zheng et al., 2019), designing a poster to solve relevant science problem (Reyna et al., 2019; Splichal et al., 2018), designing a management information software (Lin & Tsai, 2016), designing media (graphic lesson) (Mou, 2020a, 2020b), etc. All of the design activity is an iterative design process that taking time more than a day to complete. Splichal et al., (2018) concluded from their study that computer-mediated learning environment support enhancement of students' self-regulation. Whereas, there are also design activity without involvement of computer that found out to facilitate the students' self-regulation such as research conducted by Tas et al. (2019) and Kurt

& Kurt (2017). Consistent with previous section, iterative design process regardless of the learning environment whether it was mediated by computer or not, it still supports students' self-regulation. The design process and thinking could be the main aspect that support the students to maintain and improve their self-regulation.

3.1.3. Design problem/challenges in learning environments encourage students' use of self-regulation strategies

Problem/challenge in a project can encourage students' use of self-regulation thus mediate to improve their self-regulation overtime during learning process (Kurt & Kurt, 2017; Mou, 2020a, 2020b; Reyna et al., 2019; Splichal et al., 2018; Tas et al., 2019). The problem and challenge can be integrated with many lessons subject to be applied and solved by doing design. Specifically, in this paper there are some challenge or problems theme that can be integrated into learning in regard to design-based project such as; science issue (Goldstein et al., 2019; Li, Chen, et al., 2020; Li, Du, et al., 2020; Reyna et al., 2019; Splichal et al., 2018; Tas et al., 2019; Zheng et al., 2019; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), designing software program (Lin, 2018; Michel et al., 2017) and graphic media design (Kurt & Kurt, 2017; Mou, 2020b, 2020a). Nevertheless, some of the studies mainly investigating the effect of the self-regulation into the design-based project learning strategy.

There are studies that using the science concept integration such as; electrical concept (Tas et al., 2019), designing a green energy house using Energy 3D to solve energy challenges (Goldstein et al., 2019; Zheng, Xing, Huang, et al., 2020; Zheng, Xing, Zhu, et al., 2020), design a circuit to solve electrical circuit problem (Zheng et al., 2019), and generating multimedia to learn about certain challenging topic in science (Reyna et al., 2019). All of the studies integrating some challenges or problem to be solved that need to be solved by doing design. Whereas, there are three studies in this paper that investigated the relation of design project in regard to self-regulation and all of the studies showing improvement (Goldstein et al., 2019; Splichal et al., 2018; Tas et al., 2019). Science learning environment is well-suited for Design-Based Learning, as lot of the learning process in science overlaps with design thinking and process. Science also can provide vast challenges that can involve higher order thinking into learning.

In the previous section, it is showed that design project in science learning can promote students' self-regulation. In other studies, the process of designing as pure process making an artifact without the relation with disciplinary study also reported similar studies (Kurt & Kurt, 2017; Mou, 2020a, 2020b). As done by T.-Y. Mou (2020), reported enhancement of students' self-regulation as they doing 3D design project as a team. While Kurt & Kurt (2017), art students who is designing visual media in studio showing enhancement of self-regulation, though it is also supported by reflective journal. This is particularly showing that the Design-Based Learning itself regardless the subject content has positive effect towards students' self-regulation. Design thinking and design process in Design-Based Learning environment can be assumed to solely mediate students' self-regulation.

3.2. Students design capacity in Design-Based Learning environment magnifying science learning outcome

As mentioned in the previous section, the process of doing design, regardless of the content may influence positively students' self-regulation and mediate the learning outcome. Nevertheless, in learning process, this may apply in different direction. Some studies reported that students with better design capacity will enhance students' science learning outcome in design-based project (Reyna et al., 2019; Tas et al., 2019; Zheng, Xing, Huang, et al., 2020). Specifically, Zheng, Xing, Huang, et al. (2020) reported that design capacity as well as the student's prior knowledge in science magnifying the effect of students' self-regulation that eliciting their improvement on the learning outcome. Furthermore, Zheng, Xing, Zhu, et al. (2020) support the idea that they found out that students who are more experienced in design affect better learning outcome. Furthermore, other studies reported that design process itself can promote science learning in the inquiry and thinking processes while the advancement of their design skills can mediate the science learning outcome (Reyna et al., 2019; Tas et al., 2019). These findings averred that the capacity of doing design of the students mediate the science learning outcome in Design-Based Learning. This could be resulted because the design capacity itself reflecting some higher order thinking capacity that related in science learning process. Further research to investigate mainly focus on the design capacity and learning trait of the students is needed.

3.3. In Design-Based Learning environment, students' self-regulation affects students learning process and outcome

There are various reference of aspects/type self-regulations used in educational studies, but all of the self-regulation reference showing some degree or level of how high or low students. Some of the studies relate it in more detail that it connected to some other areas of students' personality trait and learning processes (Goldstein et al., 2019; Kurt & Kurt, 2017; Li, Chen, et al., 2020; Lin & Tsai, 2016; Mou, 2020b, 2020a; Reyna et al., 2019; Tas et al., 2019; Zheng, Xing, Zhu, et al., 2020; Zheng et al., 2019; Zheng, Xing, Huang, et al., 2020). As example, some studies found the relation of self-regulations in regard to design skill/performance (Li, Chen, et al., 2020), science learning outcome (Zheng, Xing, Huang, et al., 2020), participation or engagement (Zheng, Xing, Zhu, et al., 2020), reflectivity (Mou, 2020b), and self/perceived efficacy (Zheng, Xing, Zhu, et al., 2020).

3.3.1. In Design-Based Project Learning, high self-regulated learners outperformed low self-regulated learners on science learning and design skill/knowledge

High level of self-regulation greatly enhanced students' design performance (Goldstein et al., 2019; Li, Chen, et al., 2020; Splichal et al., 2018; Zheng, Xing, Zhu, et al., 2020). As stated by Li, Chen, et al. (2020), adaptive self-regulated learners can outperform minimally self-regulated learners in design completeness. Furthermore, other studies also giving some other finding of how high level of self-regulation can performed better at meeting the design goal (Goldstein et al., 2019), learning gain in task (Zheng, Xing, Zhu, et al., 2020), and project performance (Mou, 2020a). While students with high level self-regulations also showed a direct influence in better science learning outcome (Mou, 2020a; Tas et al., 2019; Zheng, Xing, Zhu, et al., 2020). Generally, high self-regulation level assumed to be positively correlated whether with science learning and design skill/knowledge, though the correlation had not investigated statistically. In design-based project environment, besides influencing the personal trait or outcome, the self-regulation levels also affect the engagement and interaction of the students (Mou, 2020a; Reyna et al., 2019; Zheng et al., 2019; Zheng, Xing, Zhu, et al., 2020). Furthermore, in the similar setting, group awareness can also be added into the learning environment to lower entropy levels and increasing interactions in the learning (Lin, 2018; Lin & Tsai, 2016). In the study related to engagement or interaction, researchers may have different aspect of benchmark. As example, engagement to metacognitive self-regulations (Zheng, Xing, Zhu, et al., 2020), contribution and participation score (Lin, 2018; Lin & Tsai, 2016), regulatory interaction in log files (Zheng et al., 2019), time spent (Mou, 2020a), and self-reported data (qualitatively) (Reyna et al., 2019). It can be argued that self-regulation of students positively influences students' engagement by many definitions whether time related, contribution, or interactions.

Mainly, higher level of self-regulation of the students, resulting higher level of engagement and participation in doing the task, while lower self-regulation level of the students resulting lower engagement and participation (Mou, 2020a; Reyna et al., 2019; Zheng et al., 2019; Zheng, Xing, Zhu, et al., 2020). Increasing their engagement in learning influenced the students to acquire knowledge more effectively (Zheng, Xing, Zhu, et al., 2020). The engagement in learning also showed to be more consistent (Zheng et al., 2019). Higher engagement level of the students also means that they give more effort and time into the task (Mou, 2020a, 2020b; Reyna et al., 2019). Generally, the quality or level of self-regulation of the students increases students' engagement in learning in terms of the students' participation, effort, and consistency in learning. Design-Based Learning in programming information management software with group awareness, showed a significant increased number of participation and interaction of each other, showing that students are more engaged in learning (Lin, 2018; Lin & Tsai, 2016). The group awareness is a supplementary setting in a collaborative project learning environment where students set their goal, plan and designing solution together (Lin & Tsai, 2016). By working collaboratively in designing plan, goal and solution together and they can evaluate each other, high level self-regulated students showing a significant improvement of personal contributions and member interactions while reducing free-rider effect (Lin, 2018; Lin & Tsai, 2016). By the Design-Based Learning environment even without supplementary, the studies approved that it can boost the student's engagement. Some of the supplementary like group awareness or peer evaluation may greatly enhance the student's engagement, though, there were no information of how significant is the difference between the common setting and supplemental setting.

3.3.2. In learning environment involving design activity, students with high self-regulation skills showing high reflectivity in the design process and learning experiences

In design-based project learning environment, students with high level of self-regulation also showed high level of reflectivity in their design process and also their learning experiences (Goldstein et al., 2019; Kurt & Kurt, 2017; Zheng, Xing, Zhu, et al., 2020). The reflective term can mean that the students were consistently evaluate their learning progress and strengthened their goals (Mou, 2020b). Highly reflective students may met their goal and solution well on learning (Goldstein et al., 2019). Moreover, high reflectivity is believed to be aspects of experienced/professional designers (Zheng, Xing, Zhu, et al., 2020). Students with high reflectivity showing a remarkable learning experiences progress that they become more aware of their potentials and strengthened their efforts towards learning (Kurt & Kurt, 2017; Mou, 2020b). Overall, we can assume that reflectivity is one aspect that represented by high self-regulated learner.

3.3.3. During the design process, students' self-regulation established a certain degree of self-efficacy or self-expectation in learning

The degree of self-regulation also influenced the students' self-efficacy or self-expectation as measured in the study (Mou, 2020a, 2020b; Zheng, Xing, Zhu, et al., 2020). Competent self-regulated learners showed a good self-awareness of their self-regulation while perceived themselves with overconfidence (Zheng, Xing, Zhu, et al., 2020). Mou (2020a), found out that that medium self-regulated learner had the highest self-expectation, while high self-regulated learners engaged more than they expected. The study also showed that the low and medium self-regulated learner were tend to be over-confident. After the completion of the project, students not only develop practical capacity in design and some degree of learning outcome but also established certain degree of self-efficacy that impact their confidence on learning (Mou, 2020b).

3.4. When doing design activity in learning, students perform a high degree of malleability in self-regulation behaviors

Students have different initial level or profile of self-regulation. During the learning progress, as the immersed in the cycle of design activity, the students' self-regulation level is dynamic and may change overtime in a diverse way from one student to another (Li, Chen, et al., 2020; Li, Du, et al., 2020; Lin & Tsai, 2016; Reyna et al., 2019; Splichal et al., 2018; Zheng et al., 2019). The dynamic process can be varied in the studies. The malleability of the self-regulation behaviors may be represented in the strategies used (Reyna et al., 2019; Splichal et al., 2018), sequences of self-regulation behavior (Splichal et al., 2018; Zheng et al., 2019), or self-regulation aspects or profile overtime (Li, Chen, et al., 2020; Lin & Tsai, 2016; Zheng et al., 2019). All of the studies showed that the self-regulation is a very dynamic process that it may very complicated and resulted diverse effect to every student.

3.4.1. Students exhibit various self-regulation strategies during the task

In facing design challenges, students need to use their regulation strategy iteratively. During the process, students used a variety of self-regulation strategies that may change diversely during the learning according to their dynamic change of self-regulation level (Reyna et al., 2019; Splichal et al., 2018). During the completion of the design assignment, students reported to use various self-regulation strategies such as help-seeking, creating their own task-strategies, or planning (time management and goal setting) to meet their final goal and expectation (Reyna et al., 2019).

Moreover, the self-regulation that augmented by the students were also diverse in trajectories from their initial profile of self-regulation, to the middle of the process, and the end of the lesson that varied between the students (Splichal et al., 2018). Generally, design-based project in a learning environment enhances the students use of self-regulation strategies in a very diverse way between one student and each other.

3.4.2. Students may show different sequence of self-regulation behaviors in design activity in learning

As mentioned before, self-regulation may change overtime in a very dynamic way. Besides being dynamic, there may also sequence of self-regulation changes that create a pattern that occur between each students' self-regulation behavior level (Splichal et al., 2018; Zheng et al., 2019). The self-regulation dynamic changes are creating a network that share similarities where the higher self-regulation level showing different density of regulation aspects which interconnected each other (Zheng et al., 2019). The findings mainly showing the evidence that student's self-regulation was changing over-time (Li, Chen, et al., 2020).

3.5. During the learning progress in a collaboration team embedded with design activities, students' self-regulation may influence the other team members' self-regulation

The interesting part of having a collaborative learning with design-based environment, it is found that self-regulation of one student may influence the other students' self-regulation, thus combination of students in a group may result different self-regulation profile in the end of the learning (Li, Du, et al., 2020; Lin, 2018; Reyna et al., 2019; Splichal et al., 2018; Zheng et al., 2019). In this paper, there are mainly two collaborative setting that resulted the findings of socially-shared self-regulation. The first one is STEM learning environment (Li, Du, et al., 2020; Zheng et al., 2019) and common collaborative project (Lin, 2018; Reyna et al., 2019). These studies showed that the dynamic social process in regard to self-regulation in collaborative setting showed to influence the dynamic of self-regulation profile of each student which is very complex.

3.5.1 Students' collaboration and socially shared-regulation augmented in STEM learning

STEM is one of setting which often need the students to work cooperatively. STEM learning using Energy 3D where students need to design a house with green renewable energy showed that the self-regulation can influence other students in process (Li, Du, et al., 2020; Zheng et al., 2019). However, the connection of the shared self-regulation is a temporal dynamic in the group level, means that the effect and changes may lose its malleability overtime (Li, Du, et al., 2020). While self-regulation sequence may also be shared during the progress increasing the dynamicity of the shared self-regulation in learning (Zheng et al., 2019). All in all, it can be assumed that STEM learning supports the self-regulation of the students that it may share to each other in the process. This finding could be a very significant point to be considered, that the learning outcome of this learning process whether soft/hard skill, thinking capacity, and diverse lesson material can be covered all at once.

3.5.2. Group with complementary support influence the socially shared self-regulation behavior

The interaction of the self-regulation can be amplified by using group awareness setting in the learning, so that students can collaborate more effectively (Lin, 2018; Reyna et al., 2019). Lin (2018) conducted a project-based learning supported by group awareness setting where students need to design a software of management –information and they need to aware of their group member's progress. The researcher found out that the setting can effectively stimulate the students to cooperate more intensely, and stimulate better to share the self-regulation from one to another. While Reyna et al., (2019), found out that during the interview with the students, one theme that established when the students maintaining their self-regulation is group support, that they need to interact and support each other during the progress. It can be averred that design-based collaborative learning well stimulated the students to socially-shared their self-regulation to others.

4. Conclusion

According to the study of the literature, design-based activity enhances the of students' self-regulation with various explanation by the study. The significance also well supported whether it is aided by the presence of computer media or not. The best explanation to describe this finding is that the iterative process of doing design process cycle and problem that faced as a challenge during the progress may develop better understanding of the students' self-conscious of their own learning progress. The process indicated that when students doing design, they employ a very malleable self-regulation strategy. This result is well-supported by evidence mostly in science subject that the design cycle processes its self-showing good effect to students' self-regulation for pure art subject. The interesting part of the literature study is that the students' self-regulation may interact with the learning subject in two ways, meaning that the better the students in the activity or project resulting better improvement and quality of self-regulation and vice versa. It also happens with the quality of design skill to their learning outcome. Students with fine skill of design may promote better learning outcome and vice versa. Furthermore, the self-regulation of each students showed that it may affect the other students' self-regulation in collaboration setting. Grounded in the findings of this research, we advocate for teachers to integrate the design process into classroom instruction irrespective of the activity's complexity. Simple forms such as guiding students to reflect on personal problems and develop contextually relevant solutions connected to subject matter may foster meaningful engagement and self-awareness. More elaborate implementations, such as STEM or project-based learning designs, can be equally effective when intentionally structured to include both individual and social regulation supported by iterative reflective cycles. These pedagogical approaches, when coupled with explicit self-regulated learning (SRL) strategies, have been shown to cultivate multifaceted benefits for students, encompassing cognitive development, social competence, and improved academic outcomes.

In this paper, there are a lot of things were assumed but due to lack of source within similar topic within the criteria, further research should be applied to investigate the reliability of the findings. It will be better if more source with loosen criteria can be included into the study so it may cover more evidences or reveal an objection. Throughout the study, the research that involve the aspect of design process or design skill in education with students' self-regulation is still scarce. This actually open up a wide door open for further research within this context. I believed that it will be fruitful if we can employ more study to the interaction of relationship within the design process and the self-regulation as it may open up a very fundamental breakthrough concept underlining how the students' can learn better for the long-term and significance not only for specific subject but well develop their quality of learning in general. There also lack of top-quality research that reported the use of media that using this context. The use of media that implement the concept within this evidence may create another level of research to be unveiled.

5. References

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