Self-Regulated Learning and Online Learning: A Systematic Review

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Abstract. Self-regulated learning (SRL) is an academically effective form of learning, which learners must set their goals and make plans before starting to learn. As an ongoing process, learners need to monitor and regulate their cognition, motivation, and behavior as well as reflect on their learning process. These processes will be repeated as a cyclic process. The emerging technologies have changed the learning environments. Technology delivers teaching to learners via online. In online learning, information of education and learners do not share the same physical setting. Online learning should provide opportunities for learners to master necessary tasks. Online learners may use SRL strategies. In this research, we have collected, synthesized, and analyzed 130 articles on various topics related to SRL that published from 1986 to 2017, focusing on online learning and mathematics. We noted several models, phases, and few other topics discussed under SRL.

Keywords: Online learning · Self-regulated learning · Strategies · Mathematics

1 Introduction

As the technology emerged, online learning had become a popular form of education today. Within the past decade, it has contributed toward a major impact on education and the trend is increasing. Online learning is a way of studying for an internationally recognized qualification without needing to attend classes. It takes place over the Internet. Online learning is catalyzing a pedagogical shift in how we teach and learn. There is a shift away from top-down lecturing and passive learners to a more interactive, collaborative approach in which learners and instructor co-create the learning process. Learners should use an appropriate strategy to make sure they can learn from the online learning environment. One of the suitable strategies is self-regulated learning (SRL).

There were many educational researchers have conducted research on SRL. Zimmerman [56] stated that American educational leaders stressed on the importance of individuals assuming personal responsibility and control for their own acquisition of knowledge and skills. The implication are the learners must become active as they are self-regulated learners. SRL requires both will and skill from the learners. Therefore

education should help learners to be aware of their own thinking, to be strategic and to direct their motivation toward valuable goals. Learners learn to be their own teachers or masters as the final goals. This means that learners need to move from teaching to self-reflective practice [59]. For this research, we will focus on mathematics subject. Mathematical understanding is typically conceived to occupational success and personal management in daily life. Therefore mathematics is a core discipline in education across primary, secondary, and higher education curricula [17]. There are many research focus on mathematics subject in relation to self-efficacy beliefs, motivation, and mathematics achievement [6, 32, 36, 40–42, 44, 49]. Usually, learners will have some difficulty in order to understand mathematical problem texts and perceiving alternative ways of solving the problems, and also a lack of confidence when calculating the solutions. Learners' problem-solving difficulties do not always from lack of mathematical knowledge but from ineffective activation of their knowledge [47]. This could happen because learners are lack of metacognitive skills that need control, monitor, and reflect on solutions processes. With the existence of online learning, learners could master the mathematics subject as there are many resources available online. In online learning, when learners use strategies that are related to self-regulation, they can regulate their personal functioning and benefit from the online learning environments.

1.1 Online Learning

The growth of technology has changed the ways of learners to study. In daily life, the learner is surrounded with digital devices and they do not need to expand extra effort to get used to them as technology is assumed to be a natural part of the environment [14]. This has given the learners more learning opportunities and help them to master in their learning. There are many definitions of online learning and it is described as a way of instruction via computer or mobile devices with Internet connections. Delen and Liew [14] said that online learning is "the use of the Internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, to acquire knowledge, to construct personal meaning, and to grow from the learning experience". Online learning also has different terms used to describe it, one of the terms is e-learning.

With the introduction of computer and Internet, online learning or e-learning tools and delivery methods have been expanded. The first Mac in 1980's enabled learners to have computers in their homes hence making it easier for them to learn about particular subjects and develop certain skills sets. Then in the following decade, virtual learning environments began truly thriving with learners can gain access to online information and e-learning opportunities [60]. These opportunities give learners to learn by themselves and enhance their skills in the study. While studying in the classroom, the instructor may not be able to focus entirely on each of learners, this will likely to cause certain learners who do not understand what have been taught. Hence learners may need to learn and revise by themselves. Therefore, online learning can play a big role and help learners to learn. While learning via online learning, learners need to use specific strategies to make sure they can learn and benefit from it. The specific strategies that learners can use are self-regulated learning.

1.2 Self-Regulated Learning

Self-regulated is not a mental ability or academic performance skills. It is defined as a self-directive process by which learners transform their mental ability into academic skills. Those abilities will control over learner's own thoughts, feelings, motivations, and actions within the external environment that relate to acts of self-regulation [5]. Those abilities of skills are important for learning both and beyond the formal learning environment.

SRL is described as being a master of their own learning [56]. The learners take control of metacognitive, motivational, and behavioral aspects of their learning [26, 33, 36, 51, 53, 56]. Self-regulated learners who plan, organize, self-instruct, self-monitor, and self-evaluate at the various stage during learning process is called metacognitive. For motivationally is where the learners perceive themselves as competent, self-efficacious, and autonomous. Lastly for behaviorally, the learners select, structure, and create environments that optimize the learning. The learners' self-regulated thoughts and actions will be oriented toward achieving the learning goals. Hence the learners become active seekers and processors of information. They are aware when they know a fact or possess a skill and when they do not. The learners also will always seek out for information when need and take necessary steps to master it. They will investigate, monitor, and modify learning to achieve the goals. These characteristics are important for learners who are near to completion of formal learnings.

There is a self-oriented feedback loop in which learners monitor the effectiveness of their learning methods or strategies and respond to feedback in a variety of ways [43]. Other article suggested a cyclical model consists of three (3) phases [57]. The first phase is called Forethought phase which includes the key processes of goal setting and social modeling to set the stage for action. Then, the second phase is Performance Control phase which involves processes that occur during learning. Finally is Self-Reflection phase which occurs after performance phase. Learners will react to their effort by self-evaluating their progress and adjusting strategies as necessary through the cyclic of processes. According to this cyclic model, SRL strategies consists of cognitive and metacognitive activities or strategies [8, 10, 18, 23, 36, 46]. The cognitive strategies are related to dealing with subject domain while metacognitive strategies are related to thinking about and regulating the cognitive. Often the term of metacognitive is simply defined as "cognitive of cognitive" or "thinking about thinking" [14, 31]. Hence, the metacognitive can be understood as a competence of reflecting on mental task critically and efficiently and effectively organize the relevant learning and thinking processes. Zimmerman [53] explains that self-regulation is not a process that occurs at the individual level but is determined by interactions with environment and also personal and behavioral influences. Learners can learn through observing and interacting with parents, teachers, peers and who demonstrate these behaviors.

There is an important aspect of theories of self-regulated learning where learners' learning and motivation are treated as interdependent processes that cannot be apart from each other. The learners are rather to seek out their opportunities to learn, to compare and to reactive to their learning outcomes. They may do self-initiated activities to promote self-observation, self-evaluation, and self-improvement. This shown that SRL involves more than a capability to execute a learning response by the learners.

Besides, it also more than a capability to adjust learning responses to new or changing conditions from the feedback. At this level, learners are not only self-directed in a metacognitive sense but are self-motivated as well.

2   Research Method

We analyzed topics that being addressed in SRL research. During our analysis, we identified several topics that being addressed. The topics are model and phases of SRL, strategies used by learners in SRL, and self-regulation in online learning environments. To examine research on SRL, we conducted a systematic review and analysis in two phases. First, we accumulated and gather related articles, and finally discuss the topics addressed in SRL.

2.1   Accumulation of Related Articles

SRL research have been published in many journals, hence we searched through thirty year period (1986–2017) of random journals. We search any journals that related to SRL, online learning and mathematics in order to get 130 articles. The articles were searched through *Google Scholar* and UiTM's library, *EzAccess*. The research articles were searched by using phrases such as "Barry Zimmerman", "self-regulated learning", "self-regulated learning and mathematics", and "self-regulated learning and academic achievement". As we looking for research articles in the topic area of SRL, we eliminated any result that was a book review.

2.2   Related Topics

Related topics that will be discussed in the findings section begin with model and phases of SRL. Although there are several types of SRL model that was invented by some researchers, all of the models is said to be a cyclic process. Learners who follow the model in order to achieve a better performance in their learning will keep the process ongoing as a circle. Then, we discussed strategies that have been suggested by researchers for the learners to follow as self-regulated learners. The strategies are cognitive, metacognitive, self-efficacy or motivation, behavior, resource management, three model of Zimmerman and 15 SRL strategies. Then we will discuss self-regulated learning in online learning. Finally, we highlight the relationship between mathematics and self-regulated learning.

3   Findings

We have collected more than 150 articles related to SRL, online learning, and mathematics. As SRL becoming an issue among educators, we can see the increasing number of articles available per year from 1998 until 2017.

3.1   Model and Phases

All the model inventors (researchers) agreed that SRL is a cyclical process, composed of different phases. However, the models present different phases and sub-processes. In general terms, we can conclude that the models have three identifiable phases. The phases are (a) preparatory that includes task analysis, planning, having goals, and setting the goals; (b) performance which the actual task is done while monitoring and controlling the progress of performance; and (c) appraisal that learners reflects, regulates and adapts for future performances. Zimmerman's and Pintrich's models emphasize a clearer distinction among the phases and sub-processes that occur within them [1, 4, 7, 11, 13, 16, 20–22, 24, 25, 29, 34, 36, 37, 50, 52, 54, 55]. For Boekaerts's, Winne and Hadwin's, and Corno and Mandinach's models are more explicit, making SRL an open process that has recursive phases [27, 38, 39].

   Winne and Hadwins's model does not make a clear distinction between the phases that belong to each that state SRL is presented as a loop that evolves over time. The Zimmerman's and Pintrich's models might allow for more specific interventions because the measurement of the effects might be more feasible. For example, if a teacher recognizes that one of the students has a motivation problem while performing a task, applying some of the subprocesses presented by Zimmerman might have a positive outcome. But for other three models, they might suggest more holistic interventions, as they perceive the SRL as a more continuous process composed of more inertial related sub-processes. Table 1 will illustrate the differences between the five different models and their phases [33].

Table 1. Phases of SRL models

Models	Preparatory phase	Performance phase	Appraisal phase
Zimmerman	Forethought – task analysis, self-motivation beliefs	Performance – self-control, self-observation	Self-reflection – self-judgement, self-reaction
Pintrich	Forethought, planning, activation	Monitoring, control	Reaction, reflection
Boekaerts	Identification, interpretation, primary and secondary appraisal, goal setting	Goal striving	Performance feedback
Corno and Mandinach	Alertness, selectivity	Connecting, planning	Monitoring
Winne and Hadwin	Task definition, goal setting, planning	Applying tactics and strategies	Adapting metacognition

3.2   Strategies in SRL

Learners can use several strategies to adapt SRL in their learning routine. In general, the learners used the same strategies and did not really different from each other. The strategies that commonly used are cognitive, metacognitive and the three phases of

Zimmerman's model. There are also other strategy which are self-efficacy, motivation, behavior, resource management, and learning strategies (motivation, concentration, information processing, and self-testing).

Cognitive and metacognitive activities or strategies are part of SRL [58]. Cognitive strategies refer to rehearsal, elaboration, and organization strategies [19, 53]. The rehearsal strategies definition is a recitation of an item that learners want to learn and say the word aloud when to read it and highlighting the text. For elaboration, it is said as paraphrase and summarize the material that being learn. When learners select the main ideas and outline the text, learners already did the organizational strategies. By having cognitive strategies, learners will be more aware of their own knowledge, for example, mathematical knowledge. They may also know their strengths and weaknesses as well as their progress in the subject.

With cognitive strategies, metacognitive strategies become critical for SRL. Metacognitive strategies are planning, goal setting, monitoring and reflection to meet the goal [14, 19, 47, 51]. The activities under this strategies are goal setting, self-monitoring, and self-evaluation. The goal setting is referred to as deciding on specific learning outcomes, while self-monitoring involves comparing the goals with current accomplishments with the use of cognitive strategies. Self-monitoring can be varied as it depends on learning context. For self-evaluation, it is a learners' self-judgment on their performance. Self-evaluation and self-monitoring occur almost at the same time. Based on the results where learners compared their performance to the goals, they will decide whether they need to change cognitive strategies or just keep going with the strategies and increase the efforts [10].

Next, resource management strategies are time and effort management, seeking help from others, seeking information, and structuring environment for learning. It depends on knowledge of the subject that learners have and what resources they can use. Activities for resource management are not directly related to cognitive and metacognitive but it is important for academic success.

Self-efficacy is learners' confidence and belief in their ability to perform a task [2, 3, 15, 35, 40, 41]. Learners with high self-efficacy tend to be confident and motivate themselves to acquire learning while for low self-efficacy learners, they have less motivation and will think that achieving goals is difficult. Learners with high self-efficacy have more effort than low self-efficacy learners when they meet obstacles in learning. Volition also important in SRL [10]. Volition is learners' will power to accomplish their goals where volition is related to the use of cognitive and resource management activities.

SRL become a cyclical phases – forethought phase, performance phase and self-reflection phase [17, 38, 43, 59]. In forethought phase, there are two processes which are task analysis and self-motivation. Task analysis involves goal setting and strategic planning. Learners will set their specific goals can increase their performance and academic success. While for self-motivation, it is related to self-efficacy that learners' beliefs they are capable of learning. The second phase is a performance that consists of self-control and self-observation. Self-control related to forethought phase where it is about the method choosing by the learners. Learners will use of imagery, self-instruction, attention focusing, and task strategies in this processes. Self-observation refers to self-recording personal events to find out the cause of the events.

3.3   SRL in Online Learning

As learners always spend most of their time outside the classroom learning environment, they tend to study via online learning. Instructors and learners will consider the methods and strategies that are used in online learning as an important issue when comparing it with traditional instruction method which is face-to-face learning. By learning via online learning, it will provide the opportunities for learners to master necessary tasks by using appropriate strategies such as SRL [7, 13, 27].

SRL is one of the methods for learner performance in both traditional and online learning. When learners use strategies of SRL, they can regulate their personal functioning and benefit from the online learning by changing their behaviors accordingly. The perception of freedom of action as learners can act according to their own wishes, expectations and need in a supportive context, where they can get resources that needed, will help them to translate their own needs, expectations and wishes into clear intentions which are goal setting. Learners need to control their own learning practice in online learning in order to benefit from it, hence self-regulated strategies are really helping them in this process. For learners who may lack strong SRL skills, external supports provided by the Internet may support and enhance learner's self-regulated learning. As learners learn by themselves through the Internet, they can get any information and resources needed.

For instance, additional resources such as image, video, graphics, and animation can provide to learners to prompt their use of information seeking strategies. This may also help learners to improve their skills and learning over time. It is accepted by researchers that learners can improve their SRL by using activities that aim at training metacognitive strategies, executive attention and emotion regulation. When studies, learners usually used SRL strategies related to note-taking, seek information and monitoring. Thus it can be stated that the use of SRL strategies can give a positive relationship with academic performance [7].

3.4   Mathematics and Online Learning

As the alternative to face-to-face learning, learners can learn mathematics subject using online learning. Learners can learn mathematics via online learning because they can get many resources on the web on this subject. This will help them to improve their skills and understanding about all topics within the subject.

The online learning conditions in these studies were less likely to be instructor-directed than they were to be learner-directed, independent learning or interactive and collaborative in nature. Online learners typically have the opportunity to practice their skills or tests their knowledge. Thus, finding of the meta-analysis is that classes with online learning on average produce stronger learner learning outcomes than do classes with solely face-to-face instruction [28].

In learner's performance and achievement, mathematics via online learning are convenient, based on metacognitive strategies that enable the learners to plan and allocate learning resources, monitor their own knowledge levels at different points during learning acquisition, as well as motivation-emotions regulation refers to learners' thoughts, actions, and behaviours when learning that affect their efforts,

persistence, and emotions when performing academic tasks [47]. These components are capable of increasing the learner's potential and performance level, moreover, learners are surrounded with digital devices in their daily life, and they do not need to expend extra effort to get used to them because "technology is assumed to be a natural part of the environment" [27].

3.5   Mathematics and SRL via Online Learning

Research on self-regulation of mathematics learning has been mainly undertaken within theoretical perspectives which are Zimmerman's model based on social-cognitive theory and theories of problem-solving. As been discuss before Zimmerman's model consists of three phases in the cyclical process. Then the theory of problem-solving is less elaborated than Zimmerman's model as the concerned of self-regulation components. It is focused on cognitive and metacognitive strategies that accompany an expert problem-solving process, namely orientation toward the task, planning a solution process or approach to the task, monitoring during task execution, evaluating the outcome, and reflecting on a solution or learning process [12].

In mathematics education, problem-solving has been a central focus. Mathematical problem solving been characterized as an activity that involves learners' engagement in cognitive strategies including accessing and using previous knowledge and experience. A successful problem solving involves coordinating previous knowledge, experiences, representations and patterns of inference, and intuition in an effort to generate new representatives of original problem-solving activity [21]. The mathematical problem solving should include experiences for learners to posing questions and formulate their own problems. Although mathematical problem solving is the most valuable aspects of mathematics, it becomes the most difficult topic for learners. Learners need to have different skills in order to have the ability to construct the solution in multi-step of processes. Hence, a coordinating framework was employed in the problem-solving process that consists of five categories. The categories are a knowledge base, problem-solving strategies, monitoring and controlling solution process, beliefs and affect, and practices. This shown that SRL and problem solving are linked to each other and help learners have better performance in their studies.

4   Discussions

From the researchers point of view, online regulated learning on mathematics strategies and methods are positive in enhancing learner's learning and knowledge [8, 9, 30, 48]. Nussbaumer et al. [31] have characterized learning strategies as purposeful, in the sense that they are consciously applied to attain the desired outcome. Learning strategies are different from study skills in that the latter can be automatized, whereas strategies require conscious effort [8]. Intrinsic motivation revealed to be the main factor predicting learners' regulation of their behavior and the learning environment. Intrinsic (belonging naturally) motivation also predicts the use of strategies indicating deep information processing, such as critical thinking and theoretical approach [48].

Some of the articles stated that online learning or blended learning can produce best features of classroom interaction and live instruction to personalize learning, allow thoughtful reflection, and differentiate instruction from learner to learner across a diverse group of learners. As we can see, the online learning represents a shift in instructional strategy and represents a fundamental shift in the way of delivery of the learning and instructional model of self-learning or distance learning. Some educators realize that the roles of schools, classrooms, and teachers are already changing. Online learning is beneficial to the learner who looks for options in learning mathematics based on their preferences. Moreover, technologies are growing fast; these advantages are the most precious ways to enhance the performance of the learner.

In developing learner's learning on mathematics via online, there is a large body of literature indicating both learning strategies and self-efficacy; both are critical to learner's success [49]. The method that always researchers examine is metacognitive, and this method is stated in many others researcher's paper [45]. Research has shown benefits from using metacognitive tools integrated to keep learners on track and remind them to use strategies such as note taking and reflection. We found that learner's study strategy and self-efficacy applied to a web-based setting or searching for information and learns using the Internet is not substantially different from learner learning in traditional developmental classes.

5   Conclusions

To achieve a better, optimal learning outcomes and performances, learners need to be self-regulated, motivated and engaged in the learning process. The emerging of technologies have changed the learning environments. Hence, we need to extend our investigation in the online learning environment and identify the effective interactions to enhance SRL of learners. More research to investigates the role of SRL in online courses will extend SRL theories to online environments and improve efforts to enhance learner's success in online courses, generally.

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