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IMPROVING STUDENTS' SELF-REGULATION USING ONLINE SELF-REGULATED LEARNING IN CHEMISTRY

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Abstract: Since the COVID-19 outbreak, there has been a significant increase in the use of online technology at all levels of education. This study was intended to investigate how online self-regulated learning (SRL) effectively promotes students' self-regulation in chemistry. The respondents in this study were 36 eleventh-grade students (15 males and 21 females) at a public high school in Indonesia in the 2020/2021 school year. In this quasi-experimental study, Online Self-regulated Learning Questionnaire (OSLQ) and semi-structured interviews were used to collect data. The results showed that students showed slightly higher self-regulation than the neutral point after the intervention. There was no significant difference between male and female students concerning self-regulation scores. The results of this study indicate that there is good interaction between students and between students and teachers during the learning process. This learning environment creates an interesting and fun atmosphere for students during the learning process. In the online SRL setting, students can design learning activities, set learning objectives and learn strategies that will be utilized. In addition, information obtained from various sources can help students construct their conceptual understanding. Thus, chemistry learning that involves students taking greater roles and responsibilities in the learning process can provide great opportunities for active participation. In short, students' self-regulation improves with the teacher's support as a facilitator in the online SRL setting.

Keywords: Self-regulated learning, self-regulation, online learning, chemistry learning.

Introduction

Since the COVID-19 outbreak, there has been a significant increase in the use of online technology at all levels of education (Strayer, 2012). In recent years, computers and the Internet have been used extensively for academic purposes during the COVID-19 pandemic (Allen & Seamann, 2009). The Internet facilitates teaching and learning in secondary education by making formal teaching and learning easier for teachers and students worldwide. Further, online learning has much potential such as meaningful learning, ease of access and increased student academic achievement (Setyosari, 2007). However, the immaturity of online learning readiness with limited facilities and Internet access to support online learning causes teaching and learning activities to be less effective. As an external factor, this is a very disturbing student activity. In addition, using an ineffective learning approach affects student activity and self-regulation, making online learning meaningless (Tumenbayar & Navchaa, 2015).

According to Zimmerman (2001), self-regulation is "the self-directive process through which learners transform their mental abilities into task-related skills". Self-regulation is seen as an attitude or behaviour of students who have the characteristics of being able to take the initiative in learning, diagnosing their learning needs, being able to set learning goals, monitoring, regulating and controlling the learning process, viewing difficulties as a challenge, being able to find and utilize relevant learning resources, selecting and implementing strategies in learning, evaluating the process and results of learning, and being able to self-concept (Sugandi, 2013). Self-regulation is related to the individual's ability to properly and effectively manage their learning experience, so self-regulation becomes an important factor

in determining student success in the learning process. Students are asked to be responsible for making decisions related to their learning process and have the ability to carry out the decisions taken (Hidayat *et al.,* 2020).

Unfortunately, previous studies reported a lack of student self-regulation. For example, Peverly *et al.* (2003) reported that college students were not good at self-regulation. Recently, Kesuma *et al.* (2021) reported low SRL of students as they needed technical direction, lacked self-confidence and had difficulty setting learning goals and managing emotions. In fact, Sahranavard *et al.* (2018) found that there is a significant correlation between self-regulation and educational performance. Kim *et al.* (2018) have also confirmed a negative relationship between self-regulation and procrastination. Accordingly, students with poor self-regulation skills tend to make less academic progress (McClelland *et al.,* 2014). In one study, students with poor self-regulation are most easily observed through difficulty sustaining attention, inability to regulate behavioural impulses effectively and challenges in handling strong emotions (Cambron *et al.,* 2017).

The low self-regulation of students should be improved using an appropriate method for example, self-regulated learning (Tumenbayar & Navchaa, 2015; Kadioglu-Akbulut & Uzuntiryaki-Kondakci, 2020). SRL trains students' ability to learn independently which is expected to increase students' abilities such as reasoning abilities and problem-solving abilities (Susatyo *et al.,* 2011). SRL combines academic learning abilities with self-control so that the learning process can occur more easily at the desired time and it can help individuals become lifelong learners whether in school, family or community. For students to self-regulate, they must be aware of their thought processes and be motivated to participate actively in their learning process (Zimmerman, 2001). In a previous study, Fredricks *et al.* (2004) stated that SRL significantly influenced the field of education. For example, SRL efficiently improves learning achievement (Zimmerman & Martinez-Pons, 1990; Pekrun *et al.,* 2002; Perry *et al.,* 2007). Also, Kadioglu-Akbulut and Uzuntiryaki-Kondakci (2020) investigated the effectiveness of self-regulation instructions developed based on guided inquiry and reported increased student achievement.

In another study, Kadıoğlu (2014) reported that self-regulation instruction succeeded in increasing self-efficacy and achievement of 11th graders in Solubility and Acid-Base Equilibrium. However, to date, there are no studies investigating the effect of SRL on students' self-regulation. In fact, self-regulation which includes task grades, performance-approach objectives, time and management of the learning environment is significantly positively correlated with learning achievement (Şen, 2016). In addition, Sahranvard *et al.* (2018) found a significant correlation between self-regulation and educational performance. Based on the abovementioned issues, efforts are needed to investigate the effect of online SRL on students' self-regulation. The online learning environment facilitates active interaction between students and teachers. Since many students are familiar and more proficient with computers and the Internet, teachers need to apply online SRL in the teaching and learning process of chemistry. In addition, teachers can take advantage of online learning platforms such as learning management systems to accommodate teaching and learning activities.

Materials and Methods

Research Design

In this study, we used a one-group posttest-only design. In this quasi-experimental design, a treatment is applied and then the dependent variable is measured once the treatment is carried out (Creswell, 2012). The treatment is online self-regulated learning and the dependent variable is self-regulation.

Participants

This study involved 36 eleventh-grade students at a public high school in Jakarta, Indonesia in

the 2020/2021 academic year. They consisted of 15 male and 21 female students aged between 17-18 years. All students participated voluntarily in this study. No additional points or incentives were given to students.

Instruments

We used the Online Self-regulated Learning Questionnaire (OSLQ) to evaluate students' self-regulation after instruction. The OSLQ designed by Barnard *et al.* (2009) who included 24 statements with 6 dimensions: Goal setting (5 items: e.g., I keep a high standard for my learning in my online courses), environment structuring (4 items: e.g., I find a comfortable place to study), task strategies (4 items: e.g., I prepare my questions before joining in the discussion forum), time management (3 items: e.g., I allocate extra studying time for my online courses because I know it is time-demanding), help-seeking (4 items: e.g., I find someone knowledgeable in course content, so that I can consult with him or her when I need help) and self-evaluation (4 items: e.g., I summarize my learning in online courses to examine my understanding of what I have learned). The Cronbach alpha coefficients for each subscale in the OSLQ ranged from 0.87 to 0.96. In addition, semi-structured interviews were used to obtain student opinions during the treatment. Some examples of questions were: *What are the problems faced during online learning?* and *What is your attitude to overcoming the problems that occur in online learning?*

Procedure

In the online SRL setting, students are taught using online self-regulated learning. This research was conducted for four meetings (4 x 90 minutes). In the first meeting, the researchers introduced the online SRL and conveyed the research purposes for the next meetings. The teacher taught the Buffer Solution at the second and third meetings using online SRL. Then, the fourth meeting was held post-OSLQ. The application of online self-regulated learning was carried out with seven learning stages: Analysis, planning, implementation, comprehensive observation, problem-solving, evaluation and modification. First, the teacher conveyed what chemistry topics would be studied and what would be done during the learning process. Students had the opportunity to analyze the characteristics of the buffer solution. Next, students were asked to plan the targets to be achieved in the buffer solution and what strategies would be carried out to succeed in getting what was targeted by writing them down. Students then implemented the plan that had been designed and the teacher asked questions to determine whether the students understood the buffer solution. Students searched and collected information from various sources to solve their problems. Students discussed and found the right solution to the problem at hand. Finally, students under the guidance of the teacher concluded the learning activities. At the end of the treatment, all students were given OSLQ and invited for an interview session.

Data Analysis

Quantitative data were analyzed using descriptive statistics including mean, standard deviation and percentage. Based on the Kolmogorov-Smirnov test, the data were normally distributed (p = 0.200; >0.05). Therefore, to examine differences in self-regulation in terms of gender, an independent-samples t-test was used. IBM SPSS Statistics version 25 was used to perform statistical analyses. Qualitative data were analyzed using Miles and Huberman's (1994) stages: Data reduction, data display and conclusion drawing/verification.

Results and Discussion

This section describes the quantitative results from the questionnaires and the qualitative results from the interviews.

Quantitative Results

Students obtained a mean score across the scale of 3.58 out of 5.00 after the intervention using online SRL (Table 1). In brief, students' self-regulation is slightly higher than the

midpoint. This shows that students have good self-regulation after treatment. Specifically, students got the highest and lowest scores on Environment Structuring (M = 3.99) and Task Strategies (M = 3.22). No significant difference was found between male and female students concerning self-regulation scores (t = 0.211; p = 0.834).

According to Table 1, female students (M = 3.592; SD = 0.292) had slightly higher self-regulation scores than males (M = 3.567; SD = 0.420). When analyzed per scale, no significant difference was found in each scale based on gender ($p > 0.05$). The results of this study indicate that an online SRL environment can be beneficial to the self-regulation of students learning chemistry. Students' self-regulation which is slightly higher than the neutral point, indicates that online SRL may be effective in stimulating students' active involvement in the learning process and helping to increase motivation to study chemistry in the current study. The high self-regulation of students may be due to continuous self-reflection so that their awareness of understanding chemistry increases (Fung *et al.*, 2019). Schraw *et al.* (2006) stated that a learning environment where students can use a process-oriented approach to ask questions, offer solutions and test results can improve student self-regulation. Therefore, the learning environment designed in SRL is relevant for students in helping them to become effective independent learners.

Qualitative Results

In general, a total of seven main stages in online SRL are presented: Analysis, plan, implementation, comprehensive observing, solving problems, evaluation and modification.

Analysis

At this stage, students organize chemical concepts understanding at the previous meeting. Thus, they can more easily understand the topic of learning that will be carried out. Before entering the core activity, the teacher conveys indicators and learning objectives to assist students in analyzing the assigned chemistry topics. Evidence of application at this stage is in the form of findings in student opinion. One student argued as follows:

Table 1: Results of *t*-test for self-regulation

Sub-scale	Gender	*N*	*M*	*SD*	*t*	*df*	*p*
Goal setting	Female	21	3.543	0.370	-0.029	34	0.977
	Male	15	3.547	0.410			
Environment structuring	Female	21	3.964	0.508	-0.300	34	0.766
	Male	15	4.017	0.530			
Task strategies	Female	21	3.226	0.499	0.057	34	0.955
	Male	15	3.217	0.490			
Time management	Female	21	3.492	0.565	0.214	34	0.832
	Male	15	3.445	0.772			
Help-seeking	Female	21	3.691	0.325	-0.149	34	0.883
	Male	15	3.717	0.713			
Self-evaluation	Female	21	3.619	0.384	10.039	34	0.306
	Male	15	3.433	0.684			
All sub-scales	Female	21	3.592	0.292	0.211	34	0.834
	Male	15	3.567	0.420			

"*The topic is a bit complicated, especially since the previous topic is still related to the current topic [buffer solution], so, I have to remember the old one too*".

(Student 20, 1 April 2021)

Student Argument 20 indicates that students carry out an analysis stage on buffer solutions. Students know that the buffer solution has a relationship with previous chemistry topics. This finding is in line with the opinion of Sesen and Tarhan (2011) that the buffer solution is included in the concept of a solution, so that when students study buffer solutions, it is necessary to have a good understanding of the topic of acid-base and stoichiometry.

Plan

At this stage, students are asked to plan the targets in the buffer solution and what strategies will be prepared to achieve what is targeted. They were instructed to write down their targets in detail. Of the 35 students who attended the first meeting, 28 students did the planning process and 7 students did not do the planning process. At the second meeting, 23 students did the planning process and 12 students did not do the planning process. This finding is evidenced by the data obtained by researchers based on instructions to students to plan learning activities.

The implementation of this stage is also proven through interviews. One student gave the following opinion:

"*Embracing learning material because I understand better if I summarize it*".

(Student 3, 1 April 2021)

"*I take notes on chemistry topics that I do not think are familiar to hear, so that I understand today's chemistry lesson*".

(Student 7, 1 April 2021)

"*The learning strategy I plan is to take notes, so I do not forget and can read it again*".

(Student 14, 1 April 2021)

The responses of the three students indicated that the buffer solution was a topic that students had not studied so they prepared strategies in the form of equipment to record a topic that was considered new. This strategy is one of the most often used by all students to support their learning success. Previous studies explain that this stage helps students to organize their learning before engaging in learning tasks (Zumbrunn *et al.,* 2011). The planning stage includes self-regulation in setting goals and task strategies. Niaz (2001) argued that the planning and goal-setting stages are complementary processes. During the planning stage, students can build critical and creative thinking skills that will help them achieve academic success. It is clear that good goal-setting and planning strategies in online learning environments help students achieve their learning goals (Kizilcec *et al.*, 2017). In addition, exposing students to goal setting is associated with high academic achievement (Peters, 2012). In a study, Sahranavard *et al.* (2018) stressed that students with higher self-regulation have better academic performance and greater motivation to learn and can make well-targeted plans. Supportively, Yang and Wang (2020) also reported that self-regulated learning positively affects students' motivation.

Implementation

Students are assigned to implement the planning program designed in the previous stage. Learning activities are carried out in two meetings. At the first meeting, the researchers presented the topic for the buffer solution using PowerPoint slides. The researchers also gave a stimulus in the form of the following questions: "Does anyone know what a buffer solution is?". It aims to attract students' initial interest and check their readiness to learn about the buffer solution. Some students gave the following answers:

Student 7: "*Can maintain the pH!*"

Student 5: "*Buffer!*"

The implementation phase focuses more on online discussion activities. The class discussion was carried out in the form of problem-solving related to the buffer solution between researchers

and students. Then, the learning activities were continued by strengthening the concept of the buffer solution in the form of practice questions followed by a discussion of questions related to differences in answers between students. At this stage, the teacher analyzes the possible differences in student answers, for example, the difference in the conjugate acid coefficient of $(NH_4)_2SO_4$. Students can also seek information from other sources to find the difference and the correct answer via the Internet. In this setting, students have support from their teachers and peers. The teacher also provides information about the correct answer and repeats a little explanation about the ionization of salt. In the literature, when the teacher offers assistance to students to reflect on themselves effectively, students have the potential to become better self-regulated learners (Berthold *et al.*, 2007; Ewijk *et al.*, 2015). The increased self-regulation of students in the current study may be attributed to this factor.

Working on practice questions is a strategy that students do quite often to help them understand buffer solutions. Their self-regulation can be seen in their commitment and how much they want and try to do the questions. Students in online SRL settings have the opportunity to self-manage. They are given the responsibility to manage the needs in the learning process, for example, the use of learning strategies. As a result, students may have been motivated to study chemistry topics and practice more self-regulated learning strategies. Thus, students will be better off if they know and are aware of what they are learning and act on their consciousness (Fauzi & Widjajanti, 2018).

Comprehensive Observing

Students observe all the learning processes. This activity is carried out so that students can have comprehensive insight and information that can increase their knowledge. A fairly good response from students is an indicator of the success of a comprehensive observation. This stage is evidenced by the findings obtained by researchers through student argument.

"*I feel active because from the beginning of the lesson, I listened to the explanation from the teacher and I also asked if I did not understand the topic*".

(Student 34, 1 April 2021)

"*For the next meeting, I hope I have understood today's topic, so that the next lesson, I will not be confused"*.

(Student 10, 8 April 2021)

The arguments above show that students are trying to do better in the next lesson. They also take the time to discuss with their teachers and peers outside the classroom. As stated by He *et al.* (2022), students who are better at preparing the environment for distance learning can improve their behaviour and increase their learning effectiveness. Students need to be more involved in their cognitive processes to resolve perceived cognitive imbalances such as not understanding a specific topic (Foster & Keane, 2015). In addition, since students are required to study before coming to online classes, in our study, peer learning also can help students increase engagement and promote their understanding of chemistry (Tullis & Goldstone, 2020). Previous studies claimed that students who develop help-seeking behaviour in the online environment are more likely to have better academic performance and achievement (Zhu *et al.*, 2011; Broadbent & Poon, 2015). Furthermore, Muis *et al.* (2018) also stressed that observations made during the learning process could update the plans that have been designed by students so that they are better in the next learning process.

Solving Problems

Students seek and collect information from various sources to solve problems. This stage is evidenced by the findings obtained by researchers from student views.

"*I was having a hard time working on it, so I asked a friend for help and tried looking it up on YouTube*".

(Student 6, 8 April 2021)

"*I find it a little difficult, so I ask a friend or look on Google*".

(Student 33, 8 April 2021)

YouTube and Google seem to be learning platforms where many students are interested in getting information about solving problems. That is, there are many learning resources that students can use to understand the learning topic. Student responses 6 and 33 indicate that there has been a problem-solving process in which students seek solutions to their problems through various learning resources. This finding is in line with the main principles in self-regulated learning that encourage group work, feedback, self-evaluation, peer assessment, problem-solving and practical activities among students (Öztürk, 2021). In the literature, providing opportunities for students to work together on problem-solving, get support from others and time planning can positively contribute to student academic performance (Öztürk, 2021). Yuningsih (2016) explained that students with good self-regulation could find concepts and learn how to solve problems independently. In an online SRL environment, students are more persistent in finding solutions to problems and are more likely to use various resources to solve them.

Evaluation

This stage provides opportunities for students to exchange ideas, ideas and opinions through small group discussions to find the right solution to the problem. This stage is proven through the researcher's diary during the learning process. The researchers asked the students, "Does anyone have a different answer for number 14?". Some students have varied answers. An example of their response is presented as follows:

Student 10: "*The answer is 4 : 1*".

Student 7: "*I answered 3 : 1*".

Student 10: "*I tried to search on the Internet, I then got 2*".

Student 23: "*I got 1*".

Based on the conversation above, students seem to be actively discussing to get the right information. During the treatment, the teacher provides students with opportunities to organize their learning process and work with their classmates. The teacher also gives students opportunities to evaluate themselves and their peers, thereby enabling them to reflect on their strengths and weaknesses and improve their performance (Öztürk, 2021). In other words, the interventions in the current study enable students to engage in learning, set goals and plan, use and evaluate independent learning strategies. As Tzeng and Nieh (2015) revealed, self-evaluation allows students to feel that their learning is effective and motivates them to continue studying hard because they believe they can make further progress. In another study, Baildon and Baildon (2008) revealed that it is important to encourage students to verify the information obtained with other sources to obtain holistic results during learning activities.

Modification

Students are encouraged to conclude what they have understood after the learning activity. The teacher asked, "After studying today, what is a buffer solution?". Students in the online SRL environment responded as follows:

"*A buffer solution is used to maintain pH when an acid, base or salt is added*".

(Student 10, 1 April 2021)

"*The quality of the buffer solution will be better if it can maintain its pH*".

(Student 34, 1 April 2021)

Based on the students' arguments above, online SRL can train students to develop conceptual understanding by concluding the learning that has been done. In a study, Dignath-van Ewijk *et al.* (2013) revealed that acceptance of knowledge is considered a process in building knowledge. In other words, students construct their knowledge by connecting new knowledge with existing knowledge. We argue that if students are trained to self-regulate early on and construct knowledge actively, they have a chance

to succeed in their future academic activities. This is consistent with previous research (e.g., Zimmerman, 2000; Pintrich, 2004) which noted that self-regulated learners tend not to give up easily in the face of difficulties, show interest in their work and try harder to succeed in complex tasks.

Conclusions and Recommendations

The effect of online self-regulated learning on students' self-regulation has been successfully investigated. The quantitative findings indicate that after the intervention using the online SRL, the students showed slightly higher self-regulation than the neutral point. In addition, there was no significant difference between male and female students regarding self-regulation scores. The results are supported by qualitative data, which shows that there has been good interaction between students and teachers during learning. This condition creates an interesting and fun atmosphere for students during learning. Even in an SRL setting, students can design learning activities, set learning objectives and learn strategies. In addition, information obtained from various sources during the application of online SRL can help students construct their conceptual understanding. Thus, learning chemistry that involves students taking greater roles and responsibilities in the learning process can provide great opportunities for active participation. The active participation of students during chemistry learning, in turn, positively impacts their performance (Olakanmi & Gumbo, 2017). This shows that students' self-regulation is improving with the teacher's support as a facilitator in an online SRL environment. In essence, online SRL can represent an alternative to conventional learning by providing the latest information to students.

In this study, self-regulated learners are students who are more active in the chemistry learning process. In SRL settings, they use a variety of learning strategies and then monitor their learning progress to achieve their learning goals. By using more self-regulation strategies, students are likely to make logical connections between prior knowledge and new information and create an appropriate learning environment. In other words, highly self-regulated learners can observe, control and improve their behaviour during learning. Due to the improved use of learning strategies, students were engaged in meaningful learning, thus, motivating them to study chemistry better (Tanriseven & Dilmac, 2013). In turn, students with high self-regulation can develop their academic efficiency and are increasingly aware of the quality of their learning.

In summary, online self-regulated learning contributes positively to students' self-regulated strategies in learning chemistry. When students have planned their goals based on their level of ability and learning resources, they tend to feel more confident in completing tasks. Moreover, this effective method helps them understand concepts in chemistry during distance learning. Therefore, improving chemistry teaching by incorporating SRL strategies can help students to understand complex concepts and motivate them to want to learn more continually. These findings prove that self-regulated learning can be an effective strategy for learning chemistry. Thus, we hope that these findings will be useful for teachers, students, curriculum designers and policymakers to create a suitable learning environment for learning chemistry during distance learning and facilitate students to achieve their learning goals.

Some recommendations are presented; it is suggested for future studies carry out similar research in different settings and subjects such as learning mathematics, language, science, etc. This was intended to determine whether similar findings were obtained in other educational contexts. In addition, the online SRL intervention lasted only four weeks in the current study. It is recommended that the instructions be applied longer in future studies. Lastly, we only used a single group; thus, future researchers are suggested to assign another group as a comparison group.

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