

Self-Regulated Learning Enhancing Scientific Literacy for Higher Educations in 21st Century Education: A Systematic Literature Review

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ABSTRACT

This study explores the importance of self-regulated learning to overcome the low level of scientific literacy in 21st-century education. This study aims to: (1) identify problems in scientific literacy, (2) explore the relationship between self-regulated learning to scientific literacy (3) explain the impact of self-regulated learning on scientific literacy. The research method uses qualitative research with a systematic literature review that analyses the literature on self-regulated learning and scientific literacy. The analysis uses Preferred Reporting Items for Systematic Review (PRISMA). The results of the study show that: (1) the problems in scientific literacy include: the relevance of the material in school to everyday life, a critical assessment of the credibility of research sources, scientific attitudes and scientific knowledge, and aspects of content, process, context and diversity of literacy (2) explores the relationship self-regulated learning in scientific literacy with self-efficacy, motivation, active learning, and engagement (3) this study finds that self-regulated learning has a positive impact on scientific literacy. This study illustrates the important role of self-regulated learning in overcoming the limitations of scientific literacy in universities.

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1. INTRODUCTION

Scientific literacy is the basis of knowledge, the basis of critical thinking skills, and the basis of everyday decision-making (Crowell & Schunn, 2016). It is one part of the basic literacy needed to support 21st-century skills (Kemdikbud, 2017). 21st-century skills include critical thinking, collaboration, communication and creativity (Trilling & Bernie, 2009). 21st-century skills also include

collaboration skills, communication, digital literacy, citizenship, problem-solving, critical thinking, creativity, and productivity (van Laar, van Deursen, van Dijk, & de Haan, 2017).

Low levels of scientific literacy are a result of current conditions on the ground. (Thomson, Hillman, & Bortoli, 2013). The results of a survey related to scientific literacy among young people in America show that they do not understand enough about science and are not interested in knowledge related to science (Cook, Druger, & Ploutz-Snyder, 2011). The problem of scientific literacy in natural science bachelor degree students at Comenius University in Bratislava, Europe, shows that the student success rate is lower than the average specified criteria, which is only 66.67%. The unsatisfactory success rate focuses on a critical assessment of the credibility of the literature sources as well as determining the elements of research design that have an impact on research results and conclusions (Čipková, Karolčík, Sládková, & Ušáková, 2018).

According to the Organization for Economic Co-operation and Development (OECD), scientific literacy includes: 1) Competence to explain scientific phenomena, 2) Competence to evaluate and design scientific investigations 3) Competence to interpret data and evidence scientifically. These three competencies are indicators in the questionnaire to determine students' scientific literacy skills. The results of distributing a questionnaire on December 20, 2021, to 16 second-semester students in the Biology course at the Al-Qur'an and Science School Sendangagung, Paciran, Lamongan showed that students' scientific literacy was low. Low scientific literacy is seen from the results of the questionnaire, which shows students who can provide results of scientific investigations are only 35.7%, the inability to explain cell concepts based on procedural knowledge and epistemic knowledge is 64.3%, and 82.1% learn cell material by memorizing it. The results of the questionnaire can be seen in Table 1 below:

Table 1. Scientific Literacy Conditions

No.	Aspects of	Questions	Student Answer (%)			
			Strongly Agree	Agree	Disagree	Strongly Disagree
1.	Competence in explaining scientific phenomena	I can present facts related to the cell concept based on laboratory results accurately.	3,6%	35,7%	53,6%	7,1%
		I can do scientific investigations in cell-related laboratories with ideal standards and appropriate procedures.		32,1%	57,1%	10,8%
		I learned cell material by memorising it.	21,4%	60,7%	17,9%	
2.	Competence in evaluating and designing scientific investigations.	I am not able to provide an assessment and evaluation of scientific investigations related to cells in the laboratory.		67,9%	32,1%	
		I am not able to deduce the concept of cells properly.		60,7%	39,3%	
		I can provide useful results of scientific investigations in the laboratory.		35,7%	57,1%	7,2%
		I am not able to propose scientific questions when discussing the cell concept.	3,6%	67,9%	25%	3,5%
3.	Competence in interpreting data and evidence scientifically.	I can interpret the results of cell investigations by making charts and tables.	3,6%	35,7%	57,1%	3,6%
		I can present cell-related data in graph or chart.				

	42,9%	57,1%
I am not able to explain the concept of cells based on procedural knowledge and epistemic knowledge.	64,3%	35,7%

National Research Council (NRC) explains that scientific literacy is the ability to use evidence and data independently to evaluate the quality of scientific information and opinions conveyed by scientists. The Program for International Student Assessment (PISA) adds that scientific literacy includes the ability to use scientific knowledge to identify questions, conclude with evidence and make decisions about changes in nature made by humans (Gormally, Brickman, & Lut, 2012). Other specific skills include a cognitive understanding of scientific research, design, and communication (Klucevsek, 2017). National Science Education Standards state that scientific literacy is needed for decision-making for individuals and society in cultural and economic aspects (Jarman & McClune, 2007).

Scientific literacy is an important competency and needs to be developed because it is a medium for developing curiosity, initiative, persistence, adaptability, leadership, and social and cultural awareness (Kemdikbud, 2017). The importance of scientific literacy in 21st-century education, according to Choi, Lee, Shin, and Kim, has five dimensions, namely: content knowledge, habits of mind, character and values, science as a human endeavour, and metacognition and self-direction. Dimension content knowledge is centred on ideas related to science so that individuals can explain and predict various phenomena and problems. Dimension habits of mind include communication skills, collaboration, and information management skills, such as determining learning resources and evaluating the quality of these resources critically. The science dimension includes understanding the collaborative and interdisciplinary nature of science. In addition, the affective domain is expanded in the dimensions of character, values and attitudes, and motivation towards science. Dimensions of metacognition and self-direction are the main dimensions of scientific literacy globally (Choi, Lee, Shin, Kim, & Krajcik, 2011). While the benefits of scientific literacy include: increasing critical thinking skills, increasing literacy related to quantitative, analyzing data appropriately, evaluating data, developing experimental designs, and increasing students' ability to argue (Krontiris-Litowitz, 2013).

Scientific literacy ability is strongly influenced by self-efficacy (Li et al., 2020). Self-efficacy is an important part of self-regulated learning (Peng, 2012). Thus, scientific literacy can be improved with self-regulated learning accompanied by self-efficacy. Self-regulated learning is a process in which students independently plan, pay attention and reflect on their thoughts, behaviors, motivations, and emotions to get learning goals (Räisänen, Postareff, Mattsson, & Lindblom-Ylänne, 2020).

Self-regulated learning refers to Bandura's social cognitive theory, which states that personal cognition is determined by behaviour and environmental factors. This theory states that humans are proactive and self-regulating organisms that are formed by external environmental influences or indirectly stimulated by genetic factors. Students' characteristics influence the learning environment's effectiveness (Sha, Looi, Chen, & Zhang, 2012). Self-regulated learning is a student's proactive action to set goal-setting abilities, self-control, manage time, and one's efforts to achieve learning goals (Tabuenca, Kalz, Drachsler, & Specht, 2015).

The theory of self-regulated learning is based on three basic assumptions (Zimmerman & Schunk, 2001). First, students can improve their learning skills using the right metacognitive and motivational strategies. The second is that students can choose, organise, and create a learning environment that is good for them. The third is that students can control and choose the type and number of instructions they need (Wang, Liu, Kee, & Chian, 2019). The advantage of self-regulated learning is that there is an active and constructive process for students to set learning goals and then try to observe, regulate and control their motivation and cognition behavior with contextual goal guidance in their environment (Schnell, Ringeisen, Raufelder, & Rohrman, 2015).

The results of Peters Burton's research entitled "Self-Regulated Learning as a Method to Develop Scientific Thinking" show that self-regulated learning in Biology students has great potential to improve scientific literacy, especially developing strategies for students to become more science-minded, especially for quiet students (Burton, 2013). Cleary, Slem, and Pawlo's research entitled "Linking student self-regulated learning profiles to achievements and engagement in mathematics" shows that self-regulated learning affects achievement and engagement (Cleary, Slem, & Pawlo, 2021).

Self-directed learning has been talked about in the past in terms of the need for scientific knowledge. Both of Peters Burton's and Cleary et al.'s studies use self-regulated learning, which affects scientific thought, accomplishments, and interest. No one has yet used self-regulated learning to help people learn more about science. So, this study is done to fill in this hole. The goals of this study are to: 1) look at problems in scientific literacy; and 2) find out how self-regulated learning, self-efficacy, motivation, active learning, and involvement relate to scientific literacy. (3) Look at how self-controlled learning affects scientific knowledge. To reach this goal, the research aims to answer the question "What are the problems with scientific literacy?" "What are the factors that affect the relationship between self-regulated learning and scientific literacy?" and "What is the effect of self-regulated learning on scientific literacy?"

The theoretical benefit of this research is to describe the important role of self-regulated learning in overcoming the limitations of scientific literacy in universities. Meanwhile, the practical benefits for students and lecturers are an effort to increase scientific literacy through self-regulated learning.

2. METHODS

This research is qualitative research with a systematic literature review approach. The analysis uses Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A systematic literature review is a systematic review by collecting some relevant and appropriate evidence with predetermined eligibility criteria to answer several research questions. Systematic literature review uses explicit and systematic methods that reduce bias in the process of identification, selection, synthesis, and study conclusions. The characteristics of a systematic review include: 1) a set of objectives that are conveyed using an explicit method and reproduced 2) a systematic search by identifying studies that meet the eligibility criteria 3) the validity assessment includes an assessment of the risk of bias 4) systematic presentation (Shamseer et al., 2015).

2.1 Search Terms

PRISMA are used to identify research sources using the following databases: Sage, Science Direct, Springer, Taylor and Francis, Wiley, and others. Search sources using several keywords including the following terms: "self-regulated learning", "scientific literacy", "higher education", and "education for the 21st century".

2.2 Selection Criteria

Several criteria are set in selecting the most relevant sources. From the two databases, there are provisions for the type of document and language. The articles used must meet the following two criteria, namely:

- a. Focusing on self-regulated learning methods.
- b. Include conceptualizations related to scientific literacy for college students.

The following criteria were chosen for self-regulated learning that can increase scientific literacy for university students in the 21st-century education era based on academic literature.

2.3 Study Selection

The step-in study selection consists of three steps. First, all articles were selected according to these two criteria. Second, the abstracts of all articles were re-filtered according to these two criteria.

Then, examine the entire text of the remaining articles. Based on existing articles, researchers classify information about the main concepts of self-regulated learning. Data classification is part of the content analysis process of the article. The final part of the content analysis process is to explain the scientific literacy competence (van Laar et al., 2017).

2.4 Analysis

The selected articles were then analyzed by meta-analysis to determine the strength between variables related to self-regulated learning to improve scientific literacy. The findings of the meta-analysis were then presented and discussed in this study (Hines, Hungerford, & Tomera, 1987).

3. FINDINGS AND DISCUSSION

The search results for articles related to "Self Regulated Learning to Improve Science Literacy for Students in the 21st Century Education Era" in the following databases: Sage, Science Direct, Springer, Wiley, and others show some findings which can be seen in table 2.

Table 2. Search Results

No.	Bibliographic Database	URL Database	Count
1.	Sage	https://journals.sagepub.com/	9 Article
2.	Science Direct	https://sciencedirect.com/	18 Article
3.	Springer	https://link.springer.com/	5 Article
4.	Wiley	https://onlinelibrary.wiley.com/	6 Article
5.	Google Scholar	https://scholar.google.com/	8 Article
6.	Taylor and Francis	https://www.tandfonline.com/	5 Article
7.	Others	-	19 Article
	Total		70 Article

Meanwhile, the search results for articles related to "Self-Regulated Learning to Improve Scientific Literacy for Students in the 21st Century Education Era" include the following keywords: scientific literacy, self-regulated learning, self-regulated learning to improve scientific literacy, PRISMA method, and 21st-century education are classified in Table 3.

Table 3. Search Results Based on Keywords

No.	Keyword	Number of
1.	Scientific Literacy	28 Article
2.	Self Regulated Learning	27 Article
3.	Self-Regulated Learning Enhancing Scientific Literacy	6 Article
4.	PRISMA Method	4 Article
5.	21 st Century Education	5 Article
	Total	70 Article

The search for these articles is expected to answer the two objectives of this research:

3.1 Problems Related to Scientific Literacy

Young people in America show that they are not sufficiently knowledgeable about science and are not interested in knowledge related to science (Cook et al., 2011). Young people who do not understand and are not interested in science are caused by the lack of relevance of school-based science to everyday life (Lawless & Brown, 2015).

Bachelor degree students in natural science the Comenius University in Bratislava, Europe, show that the success rate of students in scientific literacy is lower than the average of the specified criteria, which is 66.67%. The unsatisfactory success rate focuses on a critical assessment of the credibility of the literature sources and determining the elements of research design that impact research results and conclusions (Čipková et al., 2018). So, students' critical assessment of the credibility of literary sources and the determination of the elements of research design is still low.

The PISA evaluation in China highlights several facets of scientific literacy, including scientific attitudes, knowledge, capabilities, and scenarios (Li et al., 2020). The Trend in International Mathematics and Science Study (TIMSS) results provide insight into the state of scientific literacy in Indonesia. The survey found that in 2003, Indonesia scored an average of 411, placing it at position number 35 out of 46 countries, whereas the international average was 467. In 2007, Indonesia had a mean TIMSS score of 397, placing it 36th out of 49 countries. The international average was 500. Based on an average domestic score of 386 and an international average of 500 (Hadi & Novaliyosi, 2019), Indonesia placed 38th out of 42 nations in 2011. Indonesia ranked number 44 out of 49 countries in 2015 (Nizam, 2016). Table 4 displays these findings.

Table 4. Indonesia TIMSS results

TIMSS Result				
Year	Rank	Participants	Average Indonesian Score	Average International Score
2003	35	46 Country	411	467
2007	36	49 Country	397	500
2011	38	42 Country	386	500
2015	44	49 Country	397	500

TIMSS divides the achievement of participants into four levels, namely: low 400, intermediate 475, high 550 and advanced 625. TIMSS in 2011 and 2015 showed students who got low scores by 54%. So, it is concluded that Indonesian scientific literacy is at a low level (Rosnawati, n.d.).

Table 5. Indonesia Achievements

	TIMSS 2011				TIMSS 2015			
	Low	Medium	High	Advanced	Low	Medium	High	Advanced
Science	54%	19%	3%	0%	54%	15%	6%	0%

The findings from TIMSS above show that Indonesian children's science is at a low level. Reinforced the findings of a comparison conducted by the Organization for Economic Co-operation and Development (OECD) through the Program for International Student Assessment (PISA) in 2015 showed that the scientific literacy of Indonesian children was ranked 69th out of 76 countries (Novitasari, 2018). The results of the analysis show several findings, namely: the scientific literacy of Indonesian children is low, with an average of 32% in overall aspects, with details of 29% for content, 34% for process, and 32% for context and diversity of scientific literacy between provinces in Indonesia is low (Ardianto & Rubini, 2016).

Thus, several problems were found in scientific literacy, including 1) the relevance of the material in school to everyday life 2) a critical assessment of the credibility of research sources 3) scientific attitudes, scientific knowledge, scientific capabilities, and scientific scenarios 4) aspects of content, process, context and diversity of scientific literacy. Science educators and scientists agree that development of students scientific literacy is an important aim of science education (Gormally et al., 2012). So, there needs to be a solution that can solve the problem of scientific literacy so that the development of students' scientific literacy skills is better.

3.2 Relation Self-Regulated Learning to Scientific Literacy

The study of self-regulated learning on scientific literacy is related to several factors. The first and second factors are self-efficacy and motivation (Lai, Hwang, & Tu, 2018) because they are based on individual beliefs in carrying out difficult tasks in science. Aspects of scientific literacy, namely: attitudes, beliefs, orientation, motivation, self-efficacy, and certain values (OECD, 2017). Self-efficacy helps students in managing their learning motivation so that they are able (Caprara et al., 2008) to learn knowledge independently related to science and take the initiative in finding evidence and data in scientific investigations and ultimately increasing scientific literacy. For example, when students get a scientific investigation task, they will be motivated to carry it out and determine the goals to be achieved. Goal setting enables students to plan learning process initiatives and predict better academic performance. Students with self-efficacy will set higher research goals and have success in larger scientific investigations.

The third factor is active learning which includes the involvement of students in designing, guiding, and reflecting on their cognitive, affective, and psychomotor independence to achieve goals in the learning process (Räsänen et al., 2020). Active learning strategies affect scientific literacy through active intellectual inquiry abilities, reflection, and metacognition as well as independence in actively understanding material and not only relying on lecturer directions (Vu, 2015). For example, students who are active in a scientific investigation will set goals, research with active intellectual inquiry abilities and metacognition, and then reflect on the results of their investigations.

The fourth factor is engagement in helping students to understand knowledge contextually. Engagement in this strategy is also able to improve information retention, application of knowledge, critical thinking skills, and communication skills (Anderson, Justement, & Bruns, 2020). Thus, increasing self capabilities, and self-knowledge (Patrianingsih & Kaseng, 2016) and directing students to be more science-minded (Burton, 2013).

Based on the data above, it is explained that self-efficacy, motivation, active learning, and engagement are important factors in the self-regulated learning method in scientific literacy. Some of these factors become important factors because they relate to individual self-control. If the individual's self-control is weak, he will become less confident, not enthusiastic, passive in learning, and less involved in the learning process. So if this happens, it will result in low scientific literacy. On the other hand, if the four factors are good, then self-regulated learning in individuals is good and can improve scientific literacy skills. Following the statement that learning motivation was found as a significant mediator for scientific literacy and self-efficacy enhancing scientific literacy (Ren et al., 2020).

3.3 The Impact of Self-Regulated Learning on Scientific Literacy

Self-regulated learning can improve scientific literacy, as evidenced in the results of Peters Burton's research entitled "Self-Regulated Learning as a Method to Develop Scientific Thinking" showing that self-regulated learning in students majoring in Biology has great potential in improving scientific literacy (Burton, 2013). Self-regulated learning has three phases of the learning cycle: forethought, performance, and self-reflection. The forethought phase includes the task analysis process as well as process-oriented goal setting, such as setting the material they already know. The performance phase is the process of implementing tasks and self-monitoring. The self-reflection phase includes the process of self-assessment of the performance that has been done. If carried out continuously, the three phases of the cycle will improve scientific thinking in scientific literacy.

Scott Freeman et al's research entitled "Active Learning Increases Student Performance in Science, Engineering and Mathematics" shows that self-regulated learning can improve Science, Technology, Engineering, and Mathematical (STEM) abilities (Freeman et al., 2014). Their activities include active problem-solving related to science through group discussions and worksheets. Classroom learning activities are also combined with exercises carried out outside formal classroom sessions, such as research in the laboratory.

Yusuf Affandi, et al's research, entitled "The Effect of Student Self-Regulated Learning on Scientific Literacy through Guided Inquiry Learning" shows that self-regulated learning has a positive impact on scientific literacy (Affandi, Abdurrahman, & Suana, 2015). Some science skills include observing, classifying, predicting, measuring, concluding, and communicating using space and time relationships (Turiman, Omar, Daud, & Osman, 2012). The increase in scientific literacy with self-regulated learning is due to the good arrangement of learning strategies, high learning motivation, and good learning effectiveness.

Rosman Sadat et al's research, entitled "The Influence of Self-Regulated Learning on the Concept of Biodiversity on Scientific Literacy and Scientific Attitudes" shows that self-regulated learning can improve student scientific literacy (Rosman Sadat, 2019). Self-regulated learning directs to be actively involved in planning learning, following learning developments, and monitoring the learning process to increase learning independence. This process trains self-regulation and self-regulation so that you are aware of your potential and can use it in real life. This can improve scientific literacy because scientific literacy includes applying knowledge to the real world.

The results of the research above explain that the use of self-regulated learning methods has a major impact on scientific literacy in the current 21st-century education era. Several studies explain explicitly and implicitly related to SRL on scientific literacy. Research that implicitly explains the influence of SRL on scientific literacy is in the research of Peters Burton, Scott Freeman, and Rosman Sadat. The three studies lead to scientific thinking, student performance in science, and scientific attitude, which are also part of scientific literacy competence. At the same time, the research that explains explicitly is the research of Yusuf Affandi, which explains that self-regulated learning positively impacts scientific literacy (Affandi et al., 2015).

4. CONCLUSION

Some problems in scientific literacy include: 1) the relevance of the material in school to everyday life is not good 2) critical assessment of the credibility of research sources is not good 3) scientific attitudes, scientific knowledge, scientific capabilities, and scientific scenarios are not good 4) content aspects, process, context and diversity of scientific literacy is not good. The study of self-regulated learning in scientific literacy is related to several domains: self-efficacy Self-efficacy helps students manage their learning motivation so that they can learn knowledge independently related to science and take the initiative in finding evidence and data in scientific investigations, ultimately increasing scientific literacy. Active learning strategies affect scientific literacy through active intellectual inquiry abilities, reflection, and metacognition as well as independence in actively understanding material and not only relying on lectures' directions. Engagement in this strategy is also able to improve information retention, application of knowledge, critical thinking skills, and communication skills. Thus, increasing self capabilities, and self-knowledge and directing students to be more science-minded. Self-regulated learning is proven to have a positive impact on increasing scientific literacy. This influence is related to the following factors: the learning cycle, learning strategies, problem-solving, and the application of knowledge to the real world.

The self-regulated learning method is expected to provide a deep understanding related to the development of scientific literacy competencies for current students. Thus, it can help lecturers in science to make the teaching process more effective. This article is a reference for lecturers who want to adopt independent learning methods based on needs analysis. This article also discusses a method that is designed appropriately for the development of student scientific literacy because it also contains factors that influence SRL on scientific literacy. The results of this study are limited in research with a systematic approach to literature review. Therefore, it is hoped that further research will conduct field research related to self-regulated learning methods that can improve scientific literacy.

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