SCIENTIFIC CRITICAL THINKING MODEL TO IMPROVE SCIENTIFIC LITERACY AND SELF-REGULATION SKILLS IN BUFFER SOLUTION LEARNING

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Abstract: The low inputs, processes, and learning outputs require competency assessments in science, one of which is scientific literacy and self-regulation. This study aims to determine the differences in scientific literacy and self-regulation of students in buffer solution materials. This study is quasi-experimental using a non-equivalent control group design. The study population consisted of 205 students from the XI MIPA SMAN 7 Banjarmasin class, and sampling used purposive sampling techniques with a sample of 69 students. Data collection was carried out using test instruments in the form of multiple-choice Three Tier Tests and non-tests in the form of self-regulation questionnaires. The collected data were analyzed using Multivariate Variance Analysis (MANOVA) with the help of SPSS 27.0 software. The results of hypothesis testing show a significance of <0.05, meaning that there is a significant influence of critical thinking models on these two variables. So it can be concluded that there is an influence of scientific critical thinking models on scientific literacy abilities and students' self-regulation.

Keywords: scientific critical thinking, scientific literacy, self-regulation.

Abstrak: Rendahnya input, proses, dan output pembelajaran memerlukan penilaian kompetensi dalam bidang sains, salah satunya adalah literasi sains dan *self-regulation*. Penelitian ini bertujuan untuk mengetahui perbedaan literasi sains dan *self-regulation* siswa pada materi larutan buffer. Penelitian ini merupakan penelitian kuasi eksperimen dengan menggunakan desain non-equivalent control group design. Populasi penelitian berjumlah 205 siswa kelas XI MIPA SMAN 7 Banjarmasin, dan pengambilan sampel menggunakan teknik purposive sampling dengan sampel sebanyak 69 siswa. Pengumpulan data dilakukan dengan menggunakan instrumen tes berupa pilihan ganda Three Tier Tests dan non tes berupa angket *self-regulation*. Data yang terkumpul dianalisis menggunakan *Multivariate Variance Analysis* (MANOVA) dengan bantuan software SPSS 27.0. Hasil pengujian hipotesis menunjukkan signifikansi <0,05 artinya terdapat pengaruh signifikan model berpikir kritis terhadap kedua variabel tersebut. Jadi dapat disimpulkan bahwa terdapat pengaruh model berpikir kritis saintifik terhadap kemampuan literasi sains dan *self-regulation* siswa.

Kata Kunci: berpikir kritis ilmiah, literasi sains, regulasi diri.

INTRODUCTION

The 21st century is a century that demands advances in science and technology, so individuals who are able to compete and adapt are needed (Hasibuan & Prastowo, 2019; Nurjaya *et al*., 2020). One way to adjust to the progress of the times is through education with soft skills and hard skills that can adapt to today's needs (Hirudayaraj *et al*., 2021; Prayogi & Estetika, 2019). In the competency assessment by the Ministry of Education and Culture, there are several abilities that students must possess today, namely literacy, character, and the learning environment (Kemdikbud, 2022).

Specifically, the ability that is needed in relation to natural and social phenomena and scientific problem solving is scientific literacy (Al Sultan *et al*., 2021; Sutiani *et al*., 2021) .

The results of PISA 2018 showed that students in Indonesia ranked 71 out of 79 countries. It means the level of students' scientific literacy is low when compared to other countries. This is supported by the Computer-Based National Assessment results stating that the achievement of student literacy abilities in Indonesia is still limited to minimum competencies. In addition, the results of literacy skills in South

Kalimantan also have a moderate level of literacy ability (Kemdikbud 2021). So there is still a need for efforts to improve it both at the regional and national levels.

Scientific literacy is the involvement of individuals to understand issues related to scientific phenomena around us and ways of making scientific decisions (Ke *et al*., 2021; OECD, 2019; Sugiarti *et al*., 2021). Scientific literacy skills are fundamental in education because it is the basis of thinking and acting skills that involve a scientific way of thinking in responding to social issues of life (Natale *et al*., 2021; Valladares, 2021).

The low level of scientific literacy indicates problems in the learning process. Appropriate Iskandar *et al*. (2019); Latifah *et al*. (2020) state that low scientific literacy occurs because learners cannot solve everyday problems. This is reinforced by a preliminary study of researchers at SMAN 7 Banjarmasin, which found that students' level of scientific literacy skills was said to be relatively low. So that the right solution to improve scientific literacy is to integrate aspects of scientific literacy into the learning process (Sasmita, F.D., *et* al 2020).

Scientific literacy have a significant relationship with self-regulation, this can be seen from the low level of scientific

literacy, which will also affect low self-regulation (Birgisdottir et al, 2020); (Omarchevska et al, 2021). Therefore, scientific literacy can fundamentally train the self-regulation of learners. This is aimed at students with good scientific literacy, indirectly able to organize themselves to solve the problems they face (Kincal & Ozan, 2018; Michalsky, 2021; Susdarwati *et al.*, 2021).

Based on preliminary research on students of public senior high school 7 Banjarmasin which shows that most students still lack awareness for independent learning. Low self-regulation will have an impact on students' thinking abilities (Arif & Hayudiyani, 2017). The existence of this problem of scientific literacy and self-regulation requires a material character that has a lot to do with scientific phenomena. One of the related chemical materials is a buffer solution (Alivia & Dwiningsih, 2018; Murakami et al., 2021). The buffer solution is feasible to use to measure the level of scientific literacy and self-regulation of students. The material that closed with life of the student refers to understanding concepts actual and applicable in everyday life (Sudarmo, 2014).

The need for efforts to improve the learning process to improve scientific literacy and self-regulation can be done by applying appropriate learning methods or models (Manoharan, 2021; Zhang et al., 2021). One suitable model is Critical Thinking Learning Model (Rusmansyah et al., 2019) . However, efforts to increase scientific literacy and self-regulation have been carried out by Taofik et al. (2019); Setyaningrum et al. (2021) which show that the average value is still at the minimum. So, improvements still need to be done to get maximum results.

One model that can be used to increase literacy skills in solving problems related to natural phenomena and self-regulation optimally is the Scientific Critical Thinking (SCT) model. This refers to research by Rahman (2020) which shows that increasing science literacy using the SCT model has an N-gain value of 0.83, this is a high-quality category. So this model is used as an effort to improve the scientific literacy and self-regulation of students located at SMAN 7 Banjarmasin.

METHOD

This research is a is quasi-experimental using a non-equivalent control group design. Design of this research can be seen in the Table 1.

Table 1. Research Design

Class	*Pretest*	Treatment	*Post-test*
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

The design involves two classes, namely one control class and one experimental class. The intervention in this design is the experimental class which has been treated using the Scientific Critical Thinking (SCT) learning model and the control class which is treated using the Direct Instruction (DI) learning model. The control class and the experimental class were given a pre-test before and after learning was conducted. Syntax of the SCT Model can be seen in the Table 2.

Table 2. Syntax of SCT Learning Model

Stage
Phase 1: Student Orientation
Phase 2: Scientific activity
Phase 3: Presentation the result of Scientific activity
Phase 4: Finishing critical thinking task
Phase 5: Evaluation

Public senior high school 7 Banjarmasin for the academic year 2021/2022 is an area and research period. The population of this study were all students of class XI, totaling 205 students. The selection of the research sample was carried out using a purposive sampling technique. The sampled classes were class XI MIPA 5 and XI MIPA 2, which consisted of 63 students. Class XI

MIPA 5 is the experimental class that is given the SCT model treatment and class XI MIPA 2 is the control class with the Direct Instruction (DI) model treatment.

This study consists of independent variables and dependent variables. The independent variables in this study are the Scientific Critical Thinking (SCT) model and the Direct Instruction (DI) model. The SCT model syntax consists of 1) student orientation; 2) scientific activity; 3) presentation of the scientific activities result; 4) the completion of critical thinking tasks; and 5) evaluation. In contrast, the dependent variable in this study is scientific literacy which consists of indicators explaining scientific phenomena, directing and assessing scientific investigations, and publishing scientific data and evidence (OECD, 2019). The self-regulation questionnaire consists of indicators of remembering appropriate knowledge, making effective plans, using the necessary information, sensitive feedback, and evaluating actions (Idris, 2018).

The research instrument consisted of test and non-test. The test instrument is scientific literacy in the form of three-level multiple choice questions, and the non-test instrument is a self-regulation questionnaire. The instrument has been verified by five experts before field

testing. The results of the expert test show that the scientific literacy and self-regulation test instruments are feasible to use for research. Ten items that fulfil the requirements as scientific literacy ability test instruments have a Validity Index of more than 0.8. So the test and non-test instruments are valid and appropriate to be used as instruments in this study. The results of the reliability of the scientific literacy ability test instrument have a reliability coefficient of 0.76 which is included in the high category, so that the literacy ability test instrument can be declared feasible for use in research. While the self-regulation questionnaire out of 20 questionnaires that fulfilled the instrument requirements only 16 questionnaires.

This study's data collection was carried out through test and non-test methods (questionnaires). Scientific literacy proficiency test instruments and self-regulation questionnaires are given before and after treatment.

The use of data analysis techniques for this study is descriptive and inferential analysis techniques using variance analysis, Multivariate Analysis of Variance (MANOVA). The description analysis technique is used to describe the learners' pre-test and post-test results. Before conducting hypothesis testing with the MANOVA test, normality test. Testing of data assisted by SPSS 26.0 software. The review found that normally distributed and homogeneous data.

RESULTS AND DISCUSSION

This study aims to determine differences in scientific literacy and student self-regulation in the buffer solution material. The learning that has been carried out at Public Senior High School of 7 Banjarmasin in the context of this research is to implement the Scientific Critical Thinking (SCT) learning model to measure scientific literacy, self-regulation, and student knowledge learning outcomes. The learning process of the SCT model involves students in solving problems and gathering information so that an interactive learning process occurs that encourages students to think critically. The SCT learning model used has steps with five phases, namely a) student orientation, b) scientific activity, c) presentation of scientific activity results, d) completion of critical thinking assignments; and e) evaluation. Before conducting inferential analysis using the MANOVA test on the scientific literacy skills of the experimental and control classes, prerequisite tests were first

conducted, namely the normality test. The result of normality tests of scientific literacy and self-regulation are presented in Table 3.

Table 3. The Prerequisite Result of Scientific Literacy and Self-Regulation

Abilities	Class	N	*p* value
Scientific Literacy	Control	33	0.770
	Experiment	30	0.280
Self-Regulation	Control	33	0.438
	Experiment	30	0.530

Table 3 showed the normality test results for each class that obtained a value (Sig.) of more than 0.05. This shows that the data in the experimental class and the control class are normally distributed. After get result of normality test. Analyze data continuous to the MANOVA test. The results of the MANOVA test showed box's text of equality of covariance matrix. Based on the result is known that the value of sig. is 0.000. It means the data is not homogeneous. Even though the data is not homogeneous, the MANOVA test can be continued because the data requirements are normally distributed. The result of MANOVA can be seen in the Table 4.

Table 4. Test of Between Subjects Effects

	Mean Square	F	Sig.
Scientific Literacy	598.167	1	0.000
Self-Regulation	112.064	1	0.023

Table 4 shows the results of the Test of Between Subjects Effect. This test performs a hypothesis test on the application of the SCT model in each class. The test results show that scientific literacy has a sig. 0.000 and in slef-regulation it gets a sig value. 0.002. Making a decision whether the model affects the two dependent variables if the value of Sig. < 0.05. The Sig value on scientific literacy and self-regulation <0.05 means that there are differences in the results in the experimental class and the control class. That way, according to the draft hypothesis made, that H0 is not appropriate, and H1 is appropriate. This means that there are differences in scientific literacy abilities between students who use the SCT model and students who study with the DI model on buffer solution material (H0 is rejected and H1 is accepted).

Comparison of Scientific Literacy Levels and Self-Regulation

The next analyze in this research is comparing result of scientific literacy and sel-regulation. The result of scientific literacy level can be seen in the Table 5.

Table 5. Scientific Literacy Level of Each Competency

Scientific Literacy Competence	SCT			DI		
	Pre-test	*Post-test*	*N-Gain*	*Pre-test*	*Post-test*	*N-Gain*
Explaining scientific phenomena	38.04	93.38	0.89	37.43	89.29	0.83
Designing and evaluating scientific investigations	28.43	79.44	0.71	21.91	74.38	0.67
Interpreting data and facts scientifically	11.18	75.49	0.72	12.95	66.86	0.62
Average	**25.88**	**82.77**	**0.77**	**24.10**	**76.84**	**0.69**

Table 5 shows that there are differences in the results of the pretest and posttest in each class. The N-gain results show that the SCT class gets an N-Gain of 0.77 which is in the high category, while the DI class with an N-Gain of 0.67 is in the medium category. this means that classes using the SCT model can improve scientific literacy skills. This is in line with the research of Fauziah et al. (2019); Hamim et al. (2021); Zulfa et al. (2022) that scientific base learning is effective in improving the scientific literacy of learners.

The result of self-regulation in each indicator can be seen in the Table 6.

Table 6 Self-Regulation Level of Each Indicator

Self-Regulation Indicators	SCT		N-Gain	DI		N-Gain
	Pre-test	*Post-test*		*Pre-test*	*Post-test*	
Realizing one's own thoughts	36.32	92.06	0.88	33.57	80.43	0.71
Make a plan effectively	32.79	86.03	0.79	34.43	80.14	0.70
Utilize the necessary information	35.00	85.29	0.77	38.57	82.57	0.72
Senseiveness towards feedback	38.53	87.35	0.79	35.71	82.86	0.73
Action evaluation	36.32	87.21	0.80	37.71	82.14	0.71
Average	**35.79**	**87.59**	**0.81**	**36.00**	**81.63**	**0.71**

Table 6 shows that there are differences in the results of self-regulation abilities in the pretest and posttest in each class. The N-gain results show that both classes get N-Gain values above 0.70, which means there is an increase in the high category.

This difference is inseparable from the influence of using the SCT model in the learning process, where the SCT model has a process that has implications for scientific literacy indicators and self-regulation so that it can indirectly improve students' scientific literacy and self-regulation.

The SCT learning process is also carried out continuously in three meetings through the Student Worksheet (LKPD), thus making students more trained and skilled in literacy and arranging their patterns (Alam, 2022;

Saputra et al., 2019). The stages of SCT learning have the influence to improve each indicator of scientific literacy and self-regulation (Maksun, A. et al., 2001; Rubini, B et al., 2017).

First, the stages of student orientation are very important in helping students remember and generalize the picture of scientific phenomena that they see in everyday life, as well as indicators of realizing one's thinking from self-regulation. Meaningful activities to improve indicators are apperception interactions and student group discussions (Lai et al., 2018; Sari et al., 2021)

Secondly, the stage of scientific activity plays an essential role in improving indicators of scientific literacy, identifying questions (problems), and exploring problems, as well as indicators of effective decision-making from self-regulation. Meaningful activities to improve indicators are making investigations for solving the problems presented and practicum activities (Arisoy & Aybek, 2021; Rusmansyah et al., 2019; Yerdelen & Sungur, 2019).

Third, the stage of presentation of the results of scientific activity plays an essential role in improving scientific literacy indicators by changing data from one presentation to another, as well as using the sources of information needed by indicators from self-regulation. A meaningful activity to improve indicators is to change the data of the results from scientific activities to analysis to solve the problems presented (Doyan et al., 2020; Omarchevska et al., 2021; Rusmansyah, 2022).

Fourth, the stages of completing critical thinking tasks play an important role in improving scientific literacy indicators analyzing and interpreting (Sharon & Baram-Tsabari., 2020). Drawing conclusions and indicators using the necessary and sensitive information feedback from self-regulation, namely seen from the activities of doing critical thinking tasks, students in this activity are required to analyze and interpret data from the critical thinking problems presented (Muijs & Bokhove, 2020; Priska et al., 2021; R. Rusmansyah et al., 2019).

Fifth, the evaluation stage plays an essential role in improving indicators of identifying assumptions and evidence and evaluating investigating problems scientifically, as well as evaluating the effectiveness of actions from self-regulation indicators, namely seen from learning reflection activities (Jufrida et al., 2019; Michalsky, 2021; Rusmansyah

et al., 2019). In full, the role of the SCT model in each indicator of scientific literacy and self-regulation can be seen in Table 7.

Table 7. Relationship of SCT models with scientific literacy and self-regulation

SCT Model Steps	Indicators of Scientific Literacy	Indicators of Self-Regulation	Interpretation
Phase 1: learner orientation	Recalling knowledge is appropriate. Identify and generalize the picture.	Realizing One's Own Thoughts	able to integrate his thoughts related to scientific phenomena
Phase 2: scientific activity	Identifying questions (problems) Exploring problems scientifically	Make a plan effectively	able to identify and make a hypothesis
Phase 3: presentation of the results of scientific activity	Change data to another presentation	Using the necessary sources of information	able to transform data into an explanatory sentence
Phase 4: completion of critical thinking tasks	Analyze, and draw the right conclusions.	Sensitive to feedback	able to analyze the solution and make a conclusion
Phase 5: evaluation	Identifying evidence and reasons Evaluating the Investigation of Scientific Problems	Evaluating the effectiveness of the Action	able to evaluate related actions in solving problems

Table 7 explained that the SCT model has a relationship between the learning process, scientific literacy, and self-regulation. It is same with statement by Araujo, (2022); Macias et al., (2018) who stated that the learning process is very important to improve and update the information of each learner who is given learning so that the SCT model assessment system has a meaningful relationship in every step, which can improve students' scientific literacy and self-regulation skills in buffer solution material.

CONCLUSION

Based on the research conducted, it can be concluded that there are differences in scientific literacy and self-regulation abilities in the experimental class using the SCT model and the control class using the DI model. The N-gain results show that each ability in both classes with the SCT and DI models has increased. The results of scientific literacy in the class with the SCT model get a high category while those in the DI class get a medium category. However, it is different from the results of self-regulation, namely that both classes get the high category. this means that both models can improve scientific literacy skills or self-regulation. These results can be used for future research.

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