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Discovery Learning Model Integrated RQA to Improve Critical Thinking Skills, Metacognitive Skills and Problem-Solving Through Science Material for Junior High School Students.

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Abstract

Education should meet life's challenges in the 21st century, namely critical thinking skills, metacognitive skills, and problem-solving. The facts that have occurred have yet to be shown as expected; this can be seen from the PISA 2018, which recorded unsatisfactory results from these three aspects. This study aims to improve these three skills by developing an RQA-integrated discovery research model. The non-equivalent post-test-only control group design was used in this study—hypothesis testing using Manova analysis. The results of the study report that the discovery learning model integrated with the RQA model significantly influences critical thinking skills, metacognitive skills, and student problem-solving skills through science learning at the junior high school level. Five indicators of critical thinking skills increased after learning with the RQA integrated discovery model with an average increase of 22.19, as well as five indicators of metacognitive skills which increased by 23.44 from before learning, and six indicators of problem-solving skills also increased with an increase in score of 22.28. Students are given broad opportunities to develop their skills in managing, analyzing, and summarizing the problems they face to improve critical thinking, metacognitive, and problem-solving skills. This study result can be used as a reference for developing student skills by modifying the learning model.

Keywords: Critical Thinking, Discovery Learning, Metacognitive, Problem Solving, RQA (Reading, Questioning and Answering)

Introduction

Education should be able to prepare students to face the challenges of life in the 21st century, which requires students to have several skills, namely critical thinking skills, problem-solving skills, and metacognition (Fuad et al., 2017; National Education Association, 2014; Pacific Policy Research Center, 2010; Robinson & Kay, 2010; Saavedra & Opfer, 2012). The education model still being implemented today is a traditional education model focusing on content to answer only exam questions (Pacific Policy Research Center, 2010).

Students' critical thinking skills have yet to reach the stage where students can understand and learn to use them (Setiawati & Corebima, 2017). Students need to understand the usefulness and benefits of learning content before memorising it. Teachers only care about achieving material content if they train students' critical thinking skills (Fahim & Pezeshki, 2012; Snyder & Snyder, 2008). The results are that students cannot take advantage of the learning outcomes in real life because they assume that what they learn in class differs from what they have to face in real life (Hasan et al., 2013).

Critical thinking skills are essential in the teaching and learning process (Heard et al., 2020; Raj et al., 2022). However, some obstacles still hinder their implementation in the classroom, one of which is cultural constraints, namely the teacher's authority and the students' individualism (Junining, 2016). The teacher takes overall learning activities and makes students passive learners. The teacher has yet to explicitly develop the principles and procedures for students' critical thinking skills and only assumes that students will

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acquire independent thinking skills due to their involvement in learning (Tiruneh et al., 2014).

Besides critical thinking skills, students' metacognitive skills must also be improved. This is reflected in student gains on the 2018 PISA test placing Indonesia in rank 71 out of 78 participating countries (OECD, 2018). The results of the 2018 PISA study released by the OECD show that the ability of Indonesian students to read achieved an average score of 371, with an average OECD score of 487. Then the average score for mathematics reached 379, with an OECD average score of 487. Furthermore, for science, the average score of Indonesian students reached 389, with an OECD average score of 489 (Kemdikbud, 2019).

Learning in the classroom still uses the classical method, where students are asked to memorize several pieces of information and formulas (Bahri & Corebima, 2015; Bahri & Idris, 2017). Teachers have a minor role in creating a learning environment that can hone students' metacognitive skills (Pangestuti & Zubaidah, 2018; Susantini et al., 2018; Young & Fry, 2012). This condition causes students to need to learn the correct way of learning in dealing with learning problems. Students' lack of metacognitive abilities results in students not finding suitable learning strategies according to their character. They learn only with the concept of reading, memorizing then answering questions without being followed by an awareness of what and why it happened (Abdelrahman & Abdelrahman, 2014).

Besides the two skills above, students' problem-solving skills are also of concern. Students need to be more active when dealing with questions requiring problem-solving (Suyidno et al., 2018). Students are more comfortable with criteria C1 and C2 in the revised Bloom's taxonomy (Caliskan, 2017). Students need help dealing with story problems that emphasize problem-solving in their conclusions (Aurah, 2013; Docktor & Heller, 2009; Lee et al., 2009).

Teachers often use lower-order thinking skill questions so that students' problem-solving skills are not trained (Meier et al., 2010). Teachers are also reluctant to ask challenging questions and assume students will not solve them (Serin et al., 2012). These problems give students less opportunity to practise their thinking skills, especially problem-solving skills.

Many studies try to improve students' critical thinking skills through discovery learning (Anazifa, 2016; Canziani & Tullar, 2017; Facione et al., 2000; Fong et al., 2017; Hariyanto et al., 2022; Pangestuti & Zubaidah, 2018; Suwono et al., 2017; Wang et al., 2012). Some studies report the results obtained in improving problem-solving through discovery learning (Brenner & Parks, 2001; Serin et al., 2012; Siew & Mapeala, 2016; Thabet et al., 2017). The research seeks to improve students' metacognition with discovery learning models (Bahri & Corebima, 2015; Herlanti et al., 2017; Susantini et al., 2018). However, researchers have yet to try modifying and applying discovery learning to develop students' critical thinking, metacognitive, and problem-solving skills.

This study integrates learning *discovery* with Reading, Questioning, and Answering (RQA). Learning discovery emphasizes activity and empowerment, aiming to develop critical thinking, metacognitive, and problem-solving abilities. However, discovery learning requires a long time to allow students to read the material outside of a school environment. The RQA model can overcome this weakness: the syntax of students reading literature at home. This step allows students to obtain the data needed during the learning process *discovery*.

Integrating models *Discovery* and RQA will make it easier for students to search and find the necessary information. This learning will require critical thinking skills in finding information, sorting out information that fits the conditions needed, and analyzing information to get conclusions previously made by the problem formulation. This condition will develop their critical thinking and metacognitive skills. Another skill that can be developed in learning the *discovery* model integrated with RQA model is problem-solving. Students are taught how to solve problems contained in learning.

The model learning syntax *discovery* that has been integrated with RQA (*Reading, Questioning, and Answering*) is made by integrating the two models to fill in the gaps and weaknesses of the two models; the syntax integration is (1) *reading,* (2) *questioning,* (3) *exploration,* (4) *concept acquisition,* and (6) *concept application.*

Syntax *reading* is an activity for students to read the material provided by the teacher to stimulate questions students. This activity *reading* is carried out in their homes after receiving directions and/or giving a module by the teacher.

After reading the module/reference suggested by the teacher, students are asked to make questions (*questioning*) on the material they have read. This syntax is the first step to guide students to explore and focus on one topic, the syntax of *questioning* in RQA is similar to the problem formulation step in the syntax *Discovery*. This activity is also carried out at the homes of each student.

Exploration is the third syntax of the DisRQA model. This activity tries to explore all sources to solve questions or problem formulations that have been previously made at home. Activities *exploration* include class discussions, observation activities, practicum activities, and literature review with general references and references. The teacher's activities are *explorations* carried out in schools with teacher guidance.

The fourth syntax is *Concepts acquisition,* an activity where students arrange the concepts they have collected to build new knowledge from the information fragments they have obtained. *Concepts acquisition* will build a new concept based on students' previous problems. This activity will give birth to a solution to answer previously prepared questions; this step will lead students to conclusions and new science. This step is similar to the step *answering* in the syntax of the RQA.

Concepts application is an activity to compile the knowledge that students have obtained by asking them to solve problems in the natural environment related to the knowledge they have obtained from the four previous learning steps. Students are presented with authentic problems in the community and ask students to solve these problems. This syntax is the primary goal of the DisRQA step: to produce critical students in solving problems in the surrounding environment.

This instructional strategy should support independent learning in students. Critical thinking skills in this study used indicators adopted from Facione, namely, interpretation, analysis, evaluation, making inferences, communicating and metacognition. Metacognitive indicators adapted from Anderson & Krathwohl consist of five indicators: 1) Realizing the process of thinking and being able to describe it, 2) Developing the introduction of thinking strategies, 3) Reflecting procedures evaluative, 4) Transfer of experience knowledge and procedural in other contexts, and 5) Connect a conceptual understanding with experience.

Problem-solving indicators are taken from the rubric created by the Department of Chemical Engineering, CRCD (Project, 2002), which had six assessment indicators: 1) determining issues and the primary purpose; 2) applying prior knowledge; 3) determining information use; 4) creating and carrying out experiments; 5) analyzing and interpreting data; and 6) evaluating oneself and others with three criteria: exemplary, reasonable, and needs improvement.

Methods

Research design

The research was a quasi-experimental design with a non-equivalent posttest-only control group design (Cohen et al., 2007) designed to test students' critical thinking skills, metacognitive skills, and problem-solving through an integrated discovery learning RQA model. The assumption test was carried out in the preliminary study, and the data were reported to be homogeneous and equivalent. The research design in more detail is shown in Table 1The explorative class

Table 1: Research design

Classes	*Conduct*	*Result*
explorative	DisRQA	01
control	-	02

received instruction using the RQA integrated discovery paradigm in accordance with Table 1, while the control class was given learning using the model commonly used by the teacher. After the treatment, the explorative and control classes were given a post-test to determine critical thinking, metacognitive, and problem-solving skills.

Population and Sample

One hundred ninety-three junior high school students made up the population size for this study. A random sampling technique was chosen to determine the research sample. Two times, via lottery, 72 pupils were chosen as samples. (36 students as the explorative class and 36 as the control class).

Data Collection Tools

Scores of students' critical thinking abilities, metacognitive and problem-solving were obtained using an instrument tested for reliability and validity. Table 2 displays the grid, including the assessment dimensions for critical thinking and problem-solving abilities. The test assessment criteria are scored one if the answer is correct and 0 if the answer is incorrect. The validity of the instrument was tested using Pearson's product moment. The test findings demonstrate that, with an R-value of 0.82, every instrument item is deemed legitimate. With a coefficient of 0.79 and a very high dependability category, the Kuder-Richardson formula (KR-20) is used to calculate instrument reliabilit

Data Analysis

This study used two fundamental analyses, statistical analysis descriptive and inferential analysis Manova. Descriptive analysis calculated the mean, maximum, minimum, and standard deviation mean. Meanwhile, Manova inferential statistics were used to test the research hypotheses. The prerequisite test for the Manova test was first carried out to ensure that the data was suitable for analysis using Manova inferential statistics. Data distribution normality test, variance homogeneity test, and multivariate homogeneity test were carried out with the help of the SPSS 25 application.

Findings

Data on critical thinking and problem-solving skills were taken after students participated in RQA-integrated

Table 2. Grid instrument

Variable	*Indicator*	*Number of items*
Critical thinking skills	Interpretation	2
	Analysis	4
	Evaluation	4
	Making inferences	4
	Communicating	3
Metacognitive	Reflection on the thinking process and being able to describe it	3
	The experience of introducing thinking strategies	2
	Reflecting on evaluative procedures	2
	Transferring other procedural knowledge and contexts	2
	conceptual understanding connecting with the experience	2
Problem-solving skills	Determining issues and the primary purpose	2
	Applying prior knowledge	2
	Determining information use	2
	Creating and carrying out experiments	2
	Analyzing and interpreting data	2
	Evaluating oneself and others	2
	Total	40

Table 3: Descriptive results of group data experiment and control

Descriptive Statistics	*Experimental Group*			*Control Group*		
	Critical thinking	*Metacognitive*	*Problem-solving*	*Critical thinking*	*Metacognitive*	*Problem-solving*
N	36	36	36	36	36	36
Minimum	80	80	81	60	60	62
Maximum	93	93	97	70	70	72
Mean	86.08	87.69	89.36	63.89	64.25	67.08
Std. Deviation	3.73	3.74	3.55	2.92	2.92	2.52

discovery learning in the experimental and control groups with the usual model teacher used. The descriptive analysis of critical thinking skills and problem-solving results in the experimental and control groups are shown in Table 3. It can be seen in Table 3 that critical thinking, metacognitive and problem-solving skills in the experimental and control groups have significant differences.

Figure 1 compares the average problem-solving, metacognitive, and critical thinking results in the experimental and control groups.

Next, hypothesis testing is carried out, but before deciding on the type of analysis to be used, the data must

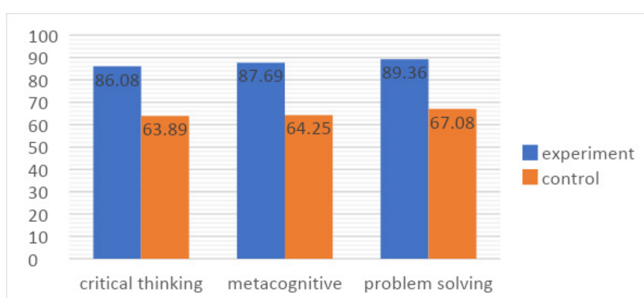

Fig. 1: Comparison of the experimental and control groups' critical thinking, metacognitive and problem-solving skills.

first be tested for prerequisites, including tests for normality of data distribution and tests for homogeneity of variance. The normality test of the data was carried out with the Kolmogorov-Smirnov value of Sig. 0.31 > 0.05. These results indicate that data on critical thinking, metacognitive and problem-solving skills come from data groups that are normally distributed. The homogeneity of variance test was conducted using Levene's test with 0.08 for critical thinking skills, 0.62 for metacognitive skills, and 0.11 for problem-solving skills. Box's Test of Equality of Variance Matrices analysis was used to test the normality of multivariate data and obtained an F value of 1,246 with a Sig value. 0.279. Based on these results, the research data is homogeneous.

Manova is used for hypothesis testing after the prerequisite test is completed, and the data may be used with inferential statistics. Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's largest root all had significance values of 0.000 (sig 0.05) according to the MANOVA test analysis results. This value shows that students who participate in learning using the integrated discovery model of the RQA model and students who adhere to the learning model often used by teachers have the significantly different critical thinking, metacognitive, and problem-solving abilities. The effect of each independent variable on the dependent variable is presented in table 4.

Testing the effects between learning models using Manova shows that the RQA integrated discovery learning model significantly affects all the independent variables studied. The results of Manova's calculation show that the critical thinking skills variable (variable X1) has a significance value of 0.000 (<0.005). The same results were also shown in the metacognitive skill variable (X2), which had a significance value of 0.000 (<0.005). As the two variables that have been mentioned, the third variable in this study is the problem-solving skills variable (X3) which also has the same significance value of 0.000 (<0.005).

Discussion

The influence of the RQA integrated discovery learning model on all variables included in this study is due to the syntax contained in the model. The RQA integrated discovery model has a reading and questioning syntax. This step trains students to develop their way of learning (metacognitive) (Bahri & Corebima, 2015). Students are given the amplest opportunity to read some literature, investigate the reading they are doing, and record all the information they do not understand in the form of question words (Hariyadi et al., 2017; Hariyanto et al., 2023). This step will practice metacognitive and critical thinking skills together in contrast

Table 4 Analysis Results of Manova Tests

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
CorrectedModel	X1	8933,389[a]	1	8933,389	943 114	.000
	X2	9234,425[b]	1	9234,425	892 254	.000
	X3	9893,556[c]	1	9893,556	878 436	.000
Intercept	X1	440547,556 46509,419	.000		440547,556	1
	X2	191477,347 30932,939	.000		191477,347	1
	X3	415568,056 36897,734	.000		415568,056	1
	X1	8933.389	1	8933.389	943 114	.000
	X2	9234,425 892,254	1		9234,425	.000
	X3	9893,556 878,436	1		9893,556	.000
Error	X1	663 056	70	9472		
	X2	433 306	70	6,190		
	X3	788 389	70	11 263		
Total	X1	450144.000	72			
	X2	191911.000	72			
	X3	426250.000	72			
Corrected Total	X1	9596.444	71			
	X2	433 653	71			
	X3	10681,944	71			

to the teacher's learning. The teacher has prepared questions and reading materials. Students need help determining which sources of information they will read and what types of questions they will seek solutions or answers to. This will cause students to become bored, and their thinking skills will not improve properly.

The exploration syntax is a step in the RQA integrated discovery model to hone students' thinking skills in finding and finding the concepts needed to answer the available problems; this will hone skills in student problem-solving (Aurah, 2013; Suyidno et al., 2018). This activity will train students to sort and choose which content can be used as a reference to answer questions or problems presented in learning. This is different from the usual learning the teacher gives in class, which only emphasizes memorizing and listening to the teacher's explanation. Students become passive learners, and their thinking skills need to be honed. Teachers need to provide more space for students to solve the problems they face on their own. Every step is always assisted and less trusted to become independent learners.

Concept acquisition provides a vast training space for students to practice their critical thinking skills (Akinbobola & Afolabi, 2009; National Education Association, 2014; Snyder & Snyder, 2008; Wang et al., 2012). Students are trained to construct new concepts from the information they previously collected. Through activities of *concept acquisition*, students are allowed by the teacher to learn how an expert makes a new concept from the pieces of information they get. This opportunity will hone students' metacognition (Abdelrahman & Abdelrahman, 2014; Gotoh, 2016; Mawaddah et al., 2015; Thomas et al., 2008). They will learn how to learn, find their weak points and strengths in learning and use this knowledge as their learning style to take advantage of their potential (Kristiani et al., 2015). At the same time, teachers often give ordinary learning has less impact on students' metacognitive development because the teacher has provided all learning steps and materials and answer opportunities. Students are less involved in searching, collecting, and processing data, so the conclusion stage is to get answers or solutions to problems.

Concept application explains why learning with the RQA integrated discovery model increases the three variables studied. The application of the concepts carried out by students cannot be separated from the scientific steps they previously did. This step is instrumental in developing their critical thinking skills (Hairida & Hadi, 2017; Lai, 2011; Paul et al., 1989; Snyder & Snyder, 2008). Problem-solving skills are also trained very well because, in this process, students will find solutions and explanations to questions previously prepared at the beginning of learning (Serin et al., 2012). In learning that the teacher often gives in class, students only receive all the material from the teacher. The teacher is an information centre to obtain all information from the teacher. Students cannot confirm and check the truth and validity of the information provided because the teacher never allows students to do this. Students are only asked to conclude the material from the data provided by the teacher. This causes students to be unskilled in thinking and not trained in developing their metacognitive skills.

The findings of several studies reported that learning based on the constructivist paradigm was able to improve student's critical thinking skills (Bahr, 2010; Canziani & Tullar, 2017; Hairida & Hadi, 2017; Pangestuti & Zubaidah, 2018) and were able to develop problem-solving skills (McDaniel & Schlager, 1990; Simon & Newell, 1970; Suyidno et al., 2018) can be a strong argument why discovery learning based on constructivism can develop the skills studied in this study. Discovery, integrated with the RQA model, can make students think and use all their potential to get problems solving as the learning objective in this model. Using concepts brought into the real world makes students more challenged in solving problems and allows them to stand on their own feet in determining the decisions. Student activity in RQA-integrated discovery learning is very high because, since the preparation of the concept, the preparation of questions to produce solutions is handled by the students themselves, and the teacher's task is only to design and supervise the learning process. Learning is highly recommended to improve critical thinking skills, metacognitive skills and skills of students' problem-solving.

Conclusion

Integrated discovery learning model RQA models significantly impact critical thinking skills, metacognitive skills of problem-solving, and students' skills through the learning of science at the junior level. The integrated discovery learning model RQA model provides the most comprehensive opportunity for students to determine the types of references they will read, formulate their questions and are given the freedom to search, collect, analyze and conclude the data they get to answer the questions they previously made. This will be by the constructivist paradigm, which emphasizes learning from concepts and building knowledge from concept pieces to produce meaningful learning. The integrated discovery learning model RQA model can also train togetherness and a high sense of responsibility because, in this step, students are grouped into small groups to jointly seek and conclude the information they find to get solutions to the problems they face. Reading and questioning will also train students' metacognitive skills to design their learning styles to get the necessary information.

References

Abdelrahman, P., & Abdelrahman, K. (2014). The Effect of Using Discovery Learning Strategy in Teaching Grammatical Rules to first year General Secondary Student on Developing Their Achievement and Metacognitive Skills. *International Journal of Innovation and Scientific Research*, *5*(2), 146–153.

Akinbobola, A. O., & Afolabi, F. (2009). Constructivist practices through guided discovery approach: The effect on students' cognitive achievements in Nigerian senior secondary school physics. *Bulgarian Journal of Science and Education Policy*, *3*(2), 233–252. http://bjsep.org/getfile.php?id=61

Anazifa, R. D. (2016). The Effect of Problem- Based Learning on Critical Thinking Skills and Student Achievement. *Proceeding of 3rd International Conference on Research, Implementation and Education of Mathematics and Science*, *May*, 43–48.

Aurah, C. M. (2013). The Effects of Self-efficacy Beliefs and Metacognition on Academic Performance: A Mixed Method Study. *American Journal of Educational Research*, *1*(8), 334–343. https://doi.org/10.12691/education-1-8-11

Bahr, N. (2010). Thinking Critically about Critical Thinking in Higher Education. *International Journal for the Scholarship of Teaching and Learning*, *4*(2). https://doi.org/10.20429/ijsotl.2010.040209

Bahri, A., & Corebima, A. D. (2015). The Contribution of Learning Motivation and Metacognitive Skill on Cognitive Learning Outcomes of Students within Different Learning Strategies. *Journal of Baltic Science Education*, *14*(4), 487–500. http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=109884227&amp%5Cnlang=ko&site=ehost-live

Bahri, A., & Idris, I. S. (2017). Teaching Thinking : Memberdayakan Keterampilan Metakognitif Mahasiswa melalui PBLRQA (Integrasi Problem-based Learning dan Reading, Questioning, & Answering). *Seminar Nasional Lembaga Penelitian UNM*, 59–69.

Brenner, D. F., & Parks, S. (2001). Cultural Influences on Critical Thinking and Problem Solving. In A. L. Costa (Ed.), *Developing Minds: A Resource Book for Teaching Thinking* (3rd ed.). the Association for Supervision and Curriculum Development (ASCD).

Caliskan, S. (2017). Physics Anxiety of Pre-Service Teachers And Their Self-Efficacy Beliefs: Differences According to Gender and Physics Achievement. *Journal of Baltic Science Education*, *16*(5), 678–693.

Canziani, B., & Tullar, W. L. (2017). Developing critical thinking through student consulting projects. *Journal of Education for Business*, *92*(6), 271–279. https://doi.org/10.1080/08832323.2017.1345849

Cohen, L., Manion, L., & Morrison, K. (2007). Research methods in education. In *Professional Development in Education* (6th ed., Vol. 38, Issue 3). Routledge. https://doi.org/10.1080/19415257.2011.643130

Docktor, J., & Heller, K. (2009). in This Context Refers To the Agreement of Scores From Multiple. *Proceedings of the NArST 2009*.

Facione, P. A., Facione, N. C., & Giancarlo, C. A. (2000). The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship to Critical Thinking Skill. *Informal Logic*, *20*(1), 61–84. https://doi.org/10.22329/il.v20i1.2254

Fahim, M., & Pezeshki, M. (2012). Manipulating Critical Thinking Skills in Test Taking. *International Journal of Education*, *4*(1), 153–160. https://doi.org/10.5296/ije.v4i1.1169

Fong, C. J., Kim, Y., Davis, C. W., Hoang, T., & Kim, Y. W. (2017). A meta-analysis on critical thinking and community college student achievement. *Thinking Skills and Creativity*, *26*. https://doi.org/10.1016/j.tsc.2017.06.002

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving junior high schools' critical thinking skills based on test three different models of learning. *International Journal of Instruction*, *10*(1), 101–116. https://doi.org/10.12973/iji.2017.1017a

Gotoh, Y. (2016). Development of Critical Thinking With Metacognitive Regulation. *International Conference on Cognition and Exploratory Learning in Digital Age*, 353–356.

Hairida, & Hadi, L. (2017). Improving Student'S Critical Thinking Skills Through Sets Vision Learning. *USEJ Unnes Science Education Journal*, *6*(2), 1561–1566.

Hariyadi, S., Corebima, A. D., Zubaidah, S., & Ibrohim. (2017). The Comparison of the Question Types in the RQA (Reading, Questioning, and Answering) Learning Model and Conventional Learning Model. *Journal of Humanities Social Sciences and Education*, *4*(7), 10–18. https://doi.org/http://dx.doi.org/10.20431/2349-0381.0407002

Hariyanto, Amin, M., Mahanal, S., & Rohman, F. (2022). Analyzing the Contribution of Critical Thinking Skills and Social Skills on Students' Character by Applying Discovery Learning Models. *International Journal of Education and Practice*, *10*(1), 42–53. https://doi.org/10.18488/61.v10i1.2907

Hariyanto, H., Hikamah, S. R., Maghfiroh, N. H., & Priawasana, E. (2023). The potential of the discovery learning model integrated the reading, questioning, and answering model on cross-cultural high school students' problem-solving skills. *Journal of Education and Learning (EduLearn)*, *17*(1), 58–66. https://doi.org/10.11591/edulearn.v17i1.20599

Hasan, S., Tumbel, F. M., & Corebima, A. D. (2013). Empowering Critical Thinking Skills in Indonesia Archipelago: Study on Elementary School Students in Ternate. *Journal of Modern Education Review*, *3*(11), 2155–7993.

Heard, Jonathan., Scoular, Claire., Duckworth, Daniel., Ramalingam, Dara., Teo, Ian., & Australian Council for Educational Research (ACER). (2020). *Critical Thinking : Skill Development Framework*. Australian Council for Educational Research. https://research.acer.edu.au/ar_misc/41

Herlanti, Y., Mardiati, Y., Wahyuningtyas, R., Mahardini, E., Iqbal, M., & Sofyan, A. (2017). Discovering learning strategy to increase metacognitive knowledge on biology learning in secondary school. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 179–186. https://doi.org/10.15294/jpii.v6i1.9605

Junining, E. (2016). Developing Critical Thinking Skills in Language Teaching : Oral Interpretation Class. *PROSIDING ICTTE FKIP UNS 2015*, *1*(1), 870–873.

Kemdikbud. (2019). *Hasil PISA Indonesia 2018*. https://www.kemdikbud.go.id/main/blog/2019/12/hasil-pisa-indonesia-2018-akses-makin-meluas-saatnya-tingkatkan-kualitas

Kristiani, N., Susilo, H., Rohman, F., & Aloysius, D. C. (2015). The contribution of students' metacognitive skills and scientific attitude towards their academic achievements in biology learning implementing Thinking Empowerment by Questioning (TEQ) learning integrated with inquiry learning (TEQI). *International Journal of Educational Policy Research and Review*, *2*(9), 113–120. https://doi.org/10.15739/IJEPRR.020

Lai, E. R. (2011). Critical thinking: A literature review. In *Pearson* (Issue June). http://images.pearsonassessments.com/images/tmrs/CriticalThinkingReviewFINAL.pdf

Lee, S. hee, Lee, J., Liu, X., Bonk, C. J., & Magjuka, R. J. (2009). A review of case-based learning practices in an online MBA program: A program-level case study. *Educational Technology and Society*, *12*(3), 178–190. https://doi.org/10.2307/jeductechsoci.12.3.178

Mawaddah, N., Suyitno, H., & Kartono. (2015). Discovery Learning Model Learning with Metacognitive Approaches to Improve Metacognition and Mathematical Creative Thinking Ability. *Unnes Journal of Mathematics Education Research*, *4*(1), 10–17.

McDaniel, M. A., & Schlager, M. S. (1990). Discovery Learning and Transfer of Problem-Solving Skills. *Cognition and Instruction*, *7*(2), 129–159.

Meier, S. L., Hovde, R. L., & Meier, R. L. (2010). Problem Solving: Teachers' Perceptions, Content Area Models, and Interdisciplinary Connections. *School Science and Mathematics*, *96*(5), 230–237. https://doi.org/10.1111/j.1949-8594.1996.tb10234.x

National Education Association. (2014). Preparing 21st Century Students for a Global Society: An Educator ' s Guide to the " Four Cs ." *National Education Association*, 1–38.

OECD. (2018). *PISA 2018*.

Pacific Policy Research Center. (2010). 21 st Century Skills for Students and Teachers. *Research & Evaluation*, *August*, 1–25.

Pangestuti, A. A., & Zubaidah, S. (2018). The Characteristics of Concept Maps Developed by the Secondary Schools and University Students. *Advances in Social Science, Education and Humanities Research*, *218*(October), 210–216. https://doi.org/10.2991/icomse-17.2018.37

Paul, R., Binker, A. J. A., Martin, D., Vetrano, C., & Kreklau, H. (1989). *Critical Thinking Handbook: 6th-9th Grades. A Guide for Remodelling Lesson Plans in Language Arts, Social Studies, & Science*. Sonoma State University.

Project, C. (2002). *Problem-Solving Rubric* (Issue August). https://wvde.state.wv.us/osp/Rubric-Problem-Solving.doc

Raj, T., Chauhan, P., Mehrotra, R., & Sharma, M. (2022). Importance of Critical Thinking in the Education. *World Journal of English Language*, *12*(3), 126–133. https://doi.org/10.5430/wjel.v12n3p126

Robinson, S. P., & Kay, K. (2010). 21St Century Knowledge and Skills in Educator Preparation. In *Education* (Issue September). https://doi.org/10.1787/9789264193864-en

Saavedra, A. R., & Opfer, V. D. (2012). Teaching and Learning 21st Century Skills: Lessons from the Learning Sciences. *Asia Society*, 35.

Serin, N. B., Ozbulak, B. E., & Serin, O. (2012). The Relationships Among Negative Thoughts, Problem Solving and Social Skills of School Psychological Consultantas. *Eurasian Journal of Educational Research*, *49*(A), 67–82.

Setiawati, H., & Corebima, A. D. (2017). Empowering Critical Thinking Skills of The Students Having Different Academic Ability in Biology Learning of Senior High School through PQ4R - TPS Strategy. *The International Journal of Social Sciences and Humanities Invention*, *4*(5), 3521–3526. https://doi.org/10.18535/ijsshi/v4i5.09

Siew, N. M., & Mapeala, R. (2016). the Effects of Problem-Based Learning With Thinking Maps on Fifth Graders' Science Critical Thinking. *Journal of Baltic Science Education*, *15*(5), 602–616.

Simon, H. A., & Newell, A. (1970). Human problem solving: The state of the theory in 1970. *American Psychologist*, *26*(2), 145–159. https://doi.org/10.1037/h0030806

Snyder, L. G., & Snyder, M. J. (2008). Teaching critical thinking and problem solving skills. *The Delta Pi Epsilon Journal*, *L*(2), 90–99. https://doi.org/10.1023/A:1009682924511

Susantini, E., Sumitro, S. B., Corebima, A. D., & Susilo, H. (2018). Improving learning process in genetics classroom by using metacognitive strategy. *Asia Pacific Education Review*, *19*(3), 401–411. https://doi.org/10.1007/s12564-018-9540-y

Suwono, H., Pratiwi, H. E., Susanto, H., & Susilo, H. (2017). Enhancement of students' biological literacy and critical thinking of biology through socio-biological case-based learning. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 213–222. https://doi.org/10.15294/jpii.v6i2.9622

Suyidno, Nur, M., Yuanita, L., Prahani, B. K., & Jatmiko, B. (2018). Effectiveness of Creative Responsibility Based Teaching (CRBT) Model on Basic Physics learning to Increase Student's Scientific Creativity and Responsibility. *Journal of Baltic Science Education*, *17*(1), 136–151.

Thabet, M., Taha, E. E.-S., Abood, S. A., & Morsy, S. R. (2017). The effect of problem-based learning on nursing students' decision making skills and styles. *Journal of Nursing Education and Practice*, *7*(6), 108–116. https://doi.org/10.5430/jnep.v7n6p108

Thomas, G., Anderson, D., & Nashon, S. (2008). Development of an instrument designed to investigate elements of science students' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education*, *30*(13), 1701–1724. https://doi.org/10.1080/09500690701482493

Tiruneh, D. T., Verburgh, A., & Elen, J. (2014). Effectiveness of Critical Thinking Instruction in Higher Education: A Systematic Review of Intervention Studies. *Higher Education Studies*, *4*(1). https://doi.org/10.5539/hes.v4n1p1

Wang, C., Boukhtiarov, A., DiBiase, W., & Steck, T. R. (2012). The Use of Open-Ended Problem-Based Learning Scenarios in an Interdisciplinary Biotechnology Class: Evaluation of a Problem-Based Learning Course Across Three Years †. *Journal of Microbiology & Biology Education*, *13*(1), 2–10. https://doi.org/10.1128/jmbe.v13i1.389

Young, A., & Fry, J. (2012). Metacognitive awareness and academic achievement in college students. *Journal of the Scholarship of Teaching and Learning*, *8*(2), 1–10. https://doi.org/10.3109/0142159X.2010.487711\\