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Implementation of PDCA Metacognitive Learning Strategies to Metacognitive Abilities, Science Process Skills, and Student Learning Outcomes

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Abstract: Students in class XI MIPA often have difficulty learning chemistry in acid and alkaline solutions because the learning process is dominated by lecture and rote learning. The use of PDCA metacognitive strategies (SM-PDCA) in the learning process can help students improve their metacognitive abilities to understand abstract concepts. This study aims to determine the implementation of learning, metacognitive abilities, science process skills, and cognitive learning outcomes of students in the SM-PDCA experimental class and expository control class (Ep), as well as the effect of applying learning. This study used a quasi-experimental design (Quasi Experiment Design) with Nonequivalent Control Group Design involving class XI MIPA as the experimental class and class XI MIPA as the control class. The results showed that: (1) the implementation of the learning process in the SM-PDCA class was 96.97% and the Ep class was 97.61% in the very good category; (2) the metacognitive abilities in the SM-PDCA class were in the high category 28.125%, while in the Ep class the high category was 6.25%, the science process skills in the SM-PDCA class were in the very high category 34.375%, while in the Ep class the category was very high 6.25 %, and the cognitive learning outcomes of students in SM-PDCA class with an average of 88.22 and Ep class of 77.64; (3) there is an effect of learning with SM-PDCA on metacognitive abilities, science process skills, and cognitive learning outcomes of students.

Keywords: PDCA Metacognitive Strategies, Metacognitive Abilities, Science Process Skills, Learning Outcomes.

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INTRODUCTION

In this day and age the development of technology and science has progressed very rapidly and is being carried out intensively. Indonesia is a country with abundant natural wealth, but Indonesia's human resources have not made the most of this wealth (Triwiyanto, 2014). As for one way to instill the necessary preparations in developing human resources, namely by education in accordance with national education goals based on Pancasila and the 1945 Constitution of the Republic of Indonesia.

The government year after year improves the curriculum in supporting education and achieving national education goals. The curriculum currently being developed is the

2013 Curriculum, also known as K-13 or Kurtilas, which was revised in 2017. The development of the 2013 Curriculum is carried out on a competency-based basis and graduation standards are set in educational units, levels of education, and educational programs.

The abilities needed by students to face the challenges of globalization in the revised 2013 Curriculum syllabus are: 1) learning and innovation skills consisting of critical thinking and being able to solve problems, being creative and innovative, as well as being able to communicate and collaborate; 2) skilled in using media, technology, information and communication (ICT); 3) the ability to lead a life and career, consisting of the ability to adapt, be flexible, take initiative, be able to develop oneself, have social and cultural abilities, be productive, be trusted, have a leadership spirit, and be responsible (Kemendikbud, 2017). This ability is needed in all subjects, especially chemistry lessons.

Chemistry is one of the subjects in natural sciences that discusses the structure, composition, properties, dynamics and energetics of substances that require reasoning and skills. Material from chemistry in the form of concepts, laws, and theories, is basically a product of a series of processes using a scientific and scientific attitude (Fadiawati, 2011). Chemistry has an abstract theory that often requires deeper explanations and descriptions in accordance with existing theories. Thus the learning that must be carried out by the teacher must provide high meaningfulness.

The problem that often occurs in learning is learning by memorizing. In addition, the facts show that learning in schools is still dominated by lecture or conventional methods (Cook, et al., 2013). The teacher only gives as much subject matter to students and tends to be forced to swallow the information provided by the teacher without a deeper thought process (Cetin-dindar & Geban, 2016), so that students have difficulty mastering chemistry lessons because of their awareness ability to thinking is still low and results in low student learning outcomes (Wibowo, 2007).

The results of Wahyudi's research (2015) showed that the average cognitive value of electrolyte and non-electrolyte solution materials using the guided inquiry learning model (83.19) was higher than students who were taught using the conventional model (74.56). The use of guided inquiry models can improve students' understanding of concepts compared to conventional models.

In connection with the abilities that students must have, a strategy, approach, or method is needed that is appropriate to support learning. One approach that can be applied in fulfilling the abilities of these students is to use a metacognitive approach (Jaunhangeer, et al., 2019). This is caused by the existence of stages that are arranged in increasing active student involvement and metacognitive awareness.

In the last 20 years, efforts to increase individual self-awareness about the importance of metacognitive have been carried out. Metacognitive abilities affect one's learning process. According to Tosun et al., (2009), metacognitive which includes individuals who are aware of knowledge, ways of learning, and are able to regulate their own learning effectively, students need to know how their minds work. That way, students have more metacognitive knowledge and more often use metacognitive strategies (Hartman, 2011). Therefore, metacognitive learning can improve students' metacognitive abilities (knowledge and skills). Individuals who have high metacognitive awareness will plan, manage information, monitor, correct errors, and evaluate better than individuals with low metacognitive awareness (Muhali, 2015).

Learning with metacognitive strategies facilitates meaningful learning by 1) connecting new topics learned to previous knowledge, 2) directing learning for a purpose (goal directing), 3) focusing learning on students (active learning), 4) supporting students to build their own understanding according to the constructivist view, 5) fostering interaction and collaboration (collaborative) between students, and 6) assessing complex abilities to determine student mastery and understanding (Parlan, et al., 2018).

Students' metacognitive abilities can be identified through metacognitive instruments, including those developed by Rompayom (2010) and the Metacognitive

Awareness Inventory (MAI) developed by Schraw (1994). Rompayom (2010) developed a metacognitive instrument that includes three aspects, namely declarative knowledge related to "related concepts", procedural knowledge related to "strategies or ways of solving", and conditional knowledge related to "reasons for using the strategy". MAI is a questionnaire to state an inventory of students' metacognitive awareness. MAI is an instrument that can measure the value of meta-cognitive knowledge which includes MAI declarative knowledge, MAI procedural knowledge, and MAI conditional knowledge (Young & Fry, 2008; Schraw & Dennison, 1994).

Previous research related to metacognitive learning in chemistry lessons reported that the average student can increase and develop metacognitive awareness at a moderate level (Nuryana & Sugiarto, 2012). In addition, Zulaihah (2019) implements metacognitive learning strategies adapted from Parlan's research (2018) which can improve students' knowledge and metacognitive skills. Zulaihah (2019) conducted research by applying the PDCA metacognitive strategy because there was still less material representation from chemistry subjects and the results of the study explained that the application of the PDCA metacognitive learning strategy was able to increase metacognitive knowledge and the learning achievement of most students at moderate levels. Therefore, Zulaihah (2019) recommends that researchers apply PDCA metacognitive learning strategies that can improve metacognitive knowledge and skills. Broadly speaking, students are able to learn chemistry well, but are not supported by skills that support their scientific processes, so that skills are needed that can support scientific processes in metacognitive learning.

A skill developed to support the scientific process is science process skills. Mulyasa (2011) says that the science process skills approach is an approach to learning that focuses on the learning process of students in acquiring skills, knowledge, attitudes, and values that can be carried out in everyday life. Science process skills have been applied in several previous studies, one of which is a combination of science process skills and the Predict, Observe, Explain (POE) learning model conducted by Iqbalia (2015). In this study it was explained that the material for acid and base solutions is a material that requires observation, classifying, making conjectures, and drawing conclusions, so that a skill is needed that supports the learning of material for acid and base solutions. The results of the study prove that the POE model can improve science process skills with the highest percentage of 96.02% through a group discussion process. However, there is still the lowest percentage of 60.68% which indicates that not all students can develop their science process skills through discussion (Iqbalia, 2015).

Ware & Rohaeti (2018) conducted a study in improving science process skills by applying a problem based learning (PBL) model. Ware & Rohaeti (2018) in their research explained that it is difficult for students to understand the concept of buffer solution material, so that science process skills are needed which can facilitate students in understanding the material. The results of the study prove that applying the PBL model can improve students' science process skills. Therefore, it is necessary to make efforts to improve students' science process skills as a whole by applying learning models or strategies and according to the characteristics of the material being studied.

METHODS

This study uses a quasi-experimental design (Quasi Experiment Design) with Nonequivalent Control Group Design and descriptive research methods. This study included two classes, namely the experimental class which was taught using the PDCA metacognitive learning strategy and the control class which was taught by expository (meaningful lecture). The expository learning strategy (Ep) is carried out in four stages, namely Preparing, Presentation, Correlation, and Generalization, while the PDCA metacognitive learning strategy (SM-PDCA) developed by (Parlan, et al., 2018) is carried out in four stages which include Preparing, Doing, Checking, and Assessing & following-up. The population of this study is all XI MIPA students at SMAN 1 Blitar for the 2019/2020 academic year with a total of 223 students divided into nine classes. While the sample is part of the population and has characteristics like the population (Sugiyono, 2017). Sampling was carried out using the cluster random sampling technique, so that the sample for this study was students of class XI SMAN 1 Blitar MIPA program with a total of 64 students, consisting of two classes, including class XI MIPA 5 as the experimental class (SM-PDCA) and XI MIPA 2 as the control class (Ep) consisting of 32 students in each class.

The research phase is divided into three, namely the preparation stage which includes the preparation of instruments and arranging research permits. The implementation stage is the implementation of each strategy in each class. Finally, the final stage includes data recording and data analysis, as well as drawing conclusions. Data analysis techniques include prerequisite tests, hypothesis testing, and correlation tests.

RESULTS

The assessment of the implementation of the learning process in both classes was observed with the help of an observation sheet which was filled in by one observer by giving a tick (√) in the column if the process was carried out during the learning process. Observation results are then averaged and presented in percentage form, then the learning criteria achieved are determined. The description of the implementation of the learning process for SM-PDCA class and Ep class can be seen in Table 1 and Figure 1.

Table 1. Average Implementation of Learning Processes for SM-PDCA Classes and Class Ep

Lesson plan	Performance Percentage (%)			
	Class SM-PDCA	Criteria	Class Ep	Criteria
Meeting 1	90,9	Very Good	100	Very Good
Meeting 2	90,9	Very Good	85,71	Good
Meeting 3	100	Very Good	100	Very Good
Meeting 4	100	Very Good	100	Very Good
Meeting 5	100	Very Good	100	Very Good
Meeting 6	100	Very Good	100	Very Good
Average	96,97		97,61	

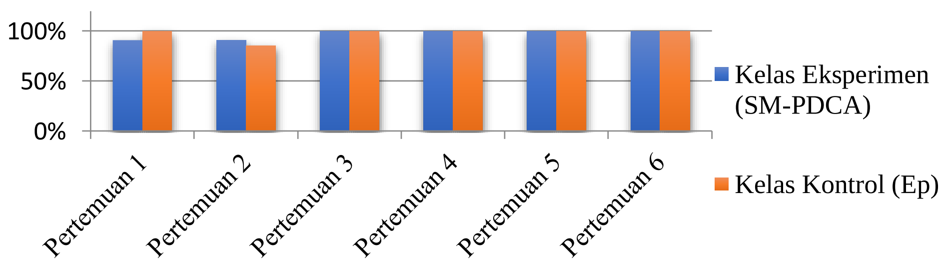

Figure 1. Percentage of Learning Success in SM-PDCA Classes and Class Ep

Based on Table 1 and Figure 1, the average percentage of implementation in the SM-PDCA class was 96.97%, while the average percentage of implementation in the Ep class was 97.61%. This proves that the implementation of the learning process in both classes has a very good category.

Analysis of the Effect of PDCA Metacognitive Strategies on Metacognitive Abilities
Metacognitive Ability Data

Data on students' metacognitive abilities were obtained from administering the Metacognitive Awareness Inventory (MAI) questionnaire before and after applying the strategy to students. Summary data on students' metacognitive abilities can be seen in Table 2 and Figure 2.

Table 2. Summary of Metacognitive Ability Data for Class SM-PDCA and Class Ep

Statistic	Class SM-PDCA (N=32)		Classs Ep (N=32)	
	Pretest	Posttest	Pretest	Posttest
Minimum Score	44,23	48,84	40,00	40,00
Maximum Score	86,15	93,85	94,23	89,23
Average	69,42	72,74	68,35	66,95
Standard Deviation	10,753	10,945	10,49	8,651

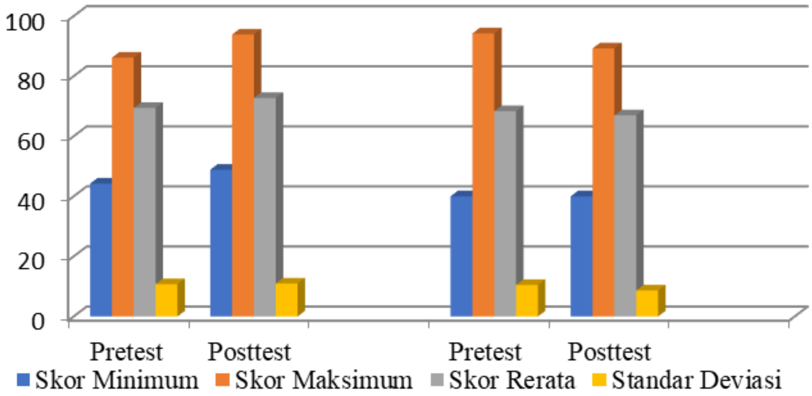

Figure 2. Metacognitive Ability Data Profile for Class SM-PDCA and Class Ep

Based on Table 2 and Figure 2 it is shown that the metacognitive abilities of the SM-PDCA class students have increased, while the metacognitive abilities of the Ep class students have decreased. To determine the increase in the metacognitive ability of students who are taught with a significantly different PDCA metacognitive strategy can be seen using a different test.

t-test

The influence of PDCA metacognitive strategies on students' metacognitive abilities was analyzed by means of a differential test on metacognitive ability score data for SM-PDCA class and Ep class. The results of the different tests on the metacognitive abilities of the SM-PDCA class and the Ep class can be seen in Table 3.

Table 3. Data Difference Test Results for Metacognitive Ability of SM-PDCA Class and Class Ep

Variable	t-test type	Significance Value	Conclussion
Metacognitive Ability	Test Independent Sample t-test	0,022	H_{01} rejected
Declarative Knowledge	Test Independent Sample t-test	0,073	H_{02} accepted
Procedural Knowledge	Mann-Whitney U test	0,184	H_{03} accepted
Conditional Knowledge	Test Independent Sample t-test	0,011	H_{04} rejected
Regulation Skills	Test Independent Sample t-test	0,034	H_{05} rejected

Based on Table 3 it is shown that the significance value of metacognitive abilities, conditional knowledge, and metacognitive regulatory skills <0.05, or H0 is rejected. This explains that there are differences in metacognitive abilities, conditional knowledge, and metacognitive regulation skills of students between the SM-PDCA class and the Ep class. Meanwhile, the significance value of declarative knowledge and procedural knowledge is >

0.05, or H0 is accepted. This explains that there is no difference in declarative knowledge and procedural knowledge between the SM-PDCA class and the Ep class.

Analysis of the Effect of PDCA Metacognitive Strategies on Science Process Skills

Science Process Skills Data

Data on students' science process skills were obtained from giving pretest and posttest questions about acid and base solutions for students in SM-PDCA class and Ep class. A summary of students' science process skills data can be seen in Table 4 and Figure 3.

Table 4. Summary of Science Process Skills Data for Class SM-PDCA and Class Ep

Statistic	Class SM-PDCA (N=32)			Classs Ep (N=32)		
	Pretest	Posttest	N-Gain	Pretest	Posttest	N-Gain
Minimum Score	26,32	47,37	0,17	21,05	52,63	0,13
Maximum Score	57,89	94,74	0,92	73,68	94,74	0,90
Average	42,44	81,43	0,69	43,26	75,99	0,58
Standard Deviation	9,817	14,031	0,20	10,068	10.773	0,18

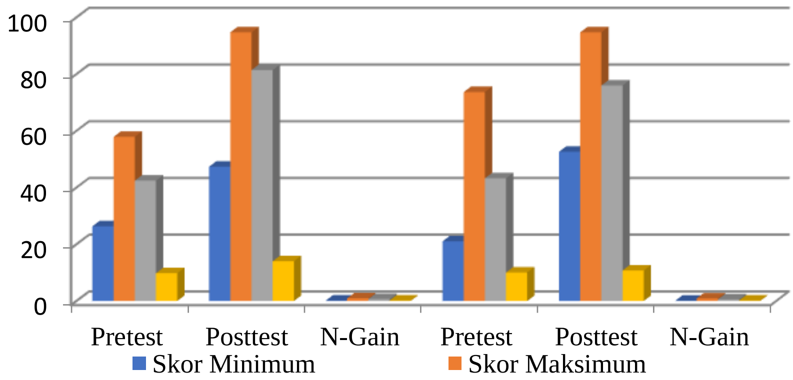

Figure 3. Data Profile of Science Process Skills for Class SM-PDCA and Class Ep

Based on Table 4 and Figure 3 it is shown that the improvement in the science process skills of the SM-PDCA class students is higher than the increase in the science process skills of the Ep class students. To determine the significant increase in the science process skills of students who are taught with PDCA metacognitive strategies that are significantly different, it can be seen by using the difference test.

Differences in the science process skills of students who were taught with PDCA metacognitive strategies compared to students who were taught with expository strategies can be seen by the Mann-Whitney U test (data not normally distributed). The results of the Mann-Whitney U test of students' science process skills can be seen in Table 5.

Table 5. Mann-Whitney U Test Results Data on Students' Science Process Skills

Class	Average	Significance Value	Conclusion
Experiment	81,43	0,021	H_0 rejected
Control	75,99		

Table 5 shows that the significance of the Mann-Whitney U test on the science process skills data for SM-PDCA class and Ep class is 0.021, sig <0.05, or H0 is rejected. This explains that there are differences in science process skills between SM-PDCA class students and Ep class.

Test the Effectiveness of N-Gain and d-effect sizes

To see the quality of improving learning using expository strategies and PDCA metacognitive strategies can be seen in the N-Gain frequency distribution. The N-Gain frequency distribution is based on the categories according to Hake (1998) which are presented in Table 6 and Figure 4.

Tabel 6. Distribusi Frekuensi N-Gain Peserta Didik Kelas SM-PDCA dan Kelas Ep

Category	Class SM-PDCA		Class Ep	
	F	%	F	%
Low	1	3,125	2	6,25
Lower Medium	4	12,5	3	9,375
Medium High	6	18,75	16	50
High	21	65,625	11	34,375

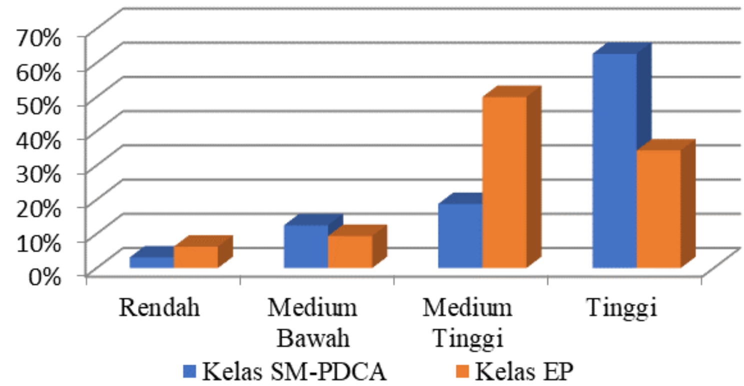

Figure 4. Comparison of the Percentage Distribution of N-Gain Science Process Skills for Class SM-PDCA and Class Ep

Based on Table 6 and Figure 4 it is known that the percentage of N-Gain distribution in the science process skills of SM-PDCA class students is in the high category of 65.625%, while the percentage of N-Gain distribution in Ep class students is in the high category of 34.375 %. This clarifies the previous conclusion that there are more students whose science process skills improved significantly in the SM-PDCA class compared to the science process skills of Ep class students.

Based on the N-Gain data that has been obtained, it can be seen that the categories are in the level of science process skills. To see the categories in the level of science process skills for SM-PDCA class and Ep class according to Agustina, et al., (2018) can be seen in Table 7 and Figure 5.

Table 7. Percentage of Science Process Skills Level Categories of SM-PDCA Class and Ep Class Students

Category	Class SM-PDCA		Class Ep	
	F	%	F	%
Very low	1	3,125	2	6,25
Low	2	6,25	3	9,375
Normal	7	21,875	14	43,75
High	11	34,375	11	34,375
Very high	11	34,375	2	6,25

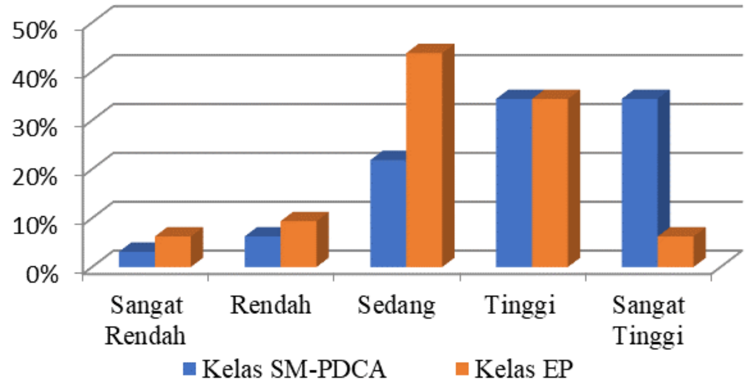

Figure 5. Comparison of the Percentage of Science Process Skill Level Categories for SMP-PDCA Classes and Class Ep

Based on Table 7 and Figure 5, it is known that the percentage of science process skills of SM-PDCA class students is in the very high category of 34.375%, while the percentage of science process skills of Ep class students is in the very high category of 6.25%. This clarifies the previous conclusion that there are more students whose science process skills improved significantly in the SM-PDCA class compared to the science process skills of Ep class students.

To find out the level of effectiveness of the SM-PDCA class and the Ep class in improving students' science process skills, the Cohen d-effect size and the mean N-Gain were calculated. The calculation results of the Cohen d-effect size and the average N-Gain can be seen in Table 8.

Table 8. Calculation results of Cohen's d-effect size and N-Gain Mean Data of Science Process Skills for SM-PDCA Class and Ep Class

	Class SM-PDCA		Class Ep	
	Result	Conclusion	Result	Conclusion
d-effect size Cohen	3,22	High or larger than normal	3,14	High or larger than normal
N-Gain Average	0,69	High	0,58	above medium

Table 8 shows that the value of Cohen's d-effect size of science process skills in both classes includes having high criteria or greater than usual, but the SM-PDCA class (d-effect size = 3.22) is higher than the Ep class (d-effect size=3,14). The average N-Gain obtained by the SM-PDCA class was 0.69 including high, while the Ep class was 0.58 including above medium. Based on the calculation of Cohen's d-effect size and the average N-Gain obtained, learning with PDCA metacognitive strategies has higher effectiveness in improving students' science process skills than classes taught with expository strategies.

Analysis of the Effect of PDCA Metacognitive Strategies on Cognitive Learning Outcomes

Cognitive Learning Outcome Data

Data on students' cognitive learning outcomes were obtained from giving pretest and posttest questions about acid and alkaline solutions for students in SM-PDCA class and Ep class. A summary of students' cognitive learning outcomes data can be seen in Table 9 and Figure 6.

Table 9. Summary of Data on Cognitive Learning Outcomes for Class SM-PDCA and Class Ep

Statistic	Class SM-PDCA (N=32)			Class Ep (N=32)		
	Pretest	Posttest	N-Gain	Pretest	Posttest	N-Gain
Minimum Score	30,77	53,85	0,33	15,38	53,85	0,14
Maximum Score	69,23	100,00	1,00	76,92	100,00	1,00

Average	50,48	88,22	0,78	50,00	77,64	0,54
Standard Deviation	9,952	11,882	0,214	12,961	11,115	0,236

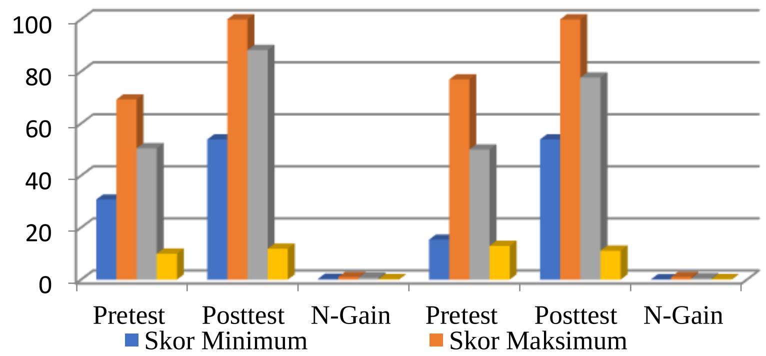

Figure 6. Data Profile of Cognitive Learning Outcomes for Class SM-PDCA and Class Ep

Based on Table 9 and Figure 6 it is shown that the increase in cognitive learning outcomes of SM-PDCA class students is higher than the increase in cognitive learning outcomes of Ep class students. To determine the increase in cognitive learning outcomes of students who are taught with PDCA metacognitive strategies that are significantly different, it can be seen by using the difference test.

T-test

Differences in the cognitive learning outcomes of students who were taught with the PDCA metacognitive strategy compared to students who were taught with the expository strategy can be seen by the Mann-Whitney U test (data not normally distributed). The results of the Mann-Whitney U test for students' cognitive learning outcomes can be seen in Table 10.

Table 10. Mann-Whitney U Test Results Data on Students' Cognitive Learning Outcomes

Class	Average Value	Significance Value	Conclusion
Experiment	88,22	0,000	H_0 rejected
Control	77,64		

Table 10 shows that the significance of the Mann-Whitney U test on cognitive learning outcomes data for SM-PDCA class and Ep class is 0.000, sig <0.05, or H0 is rejected. This explains that there are differences in cognitive learning outcomes between SM-PDCA class students and Ep class.

To see the quality of improving learning using expository strategies and PDCA metacognitive strategies can be seen in the N-Gain frequency distribution. The N-Gain frequency distribution is based on the categories according to Hake (1998) which are presented in Table 11 and Figure 7.

Table 11. N-Gain Frequency Distribution of Students in Class SM-PDCA and Class Ep

Category	Class SM-PDCA		Class Ep	
	F	%	F	%
Low	0	0	2	6,25
Lower Medium	4	12,5	11	34,375
Medium High	2	6,25	8	25
High	26	81.25	11	34,375

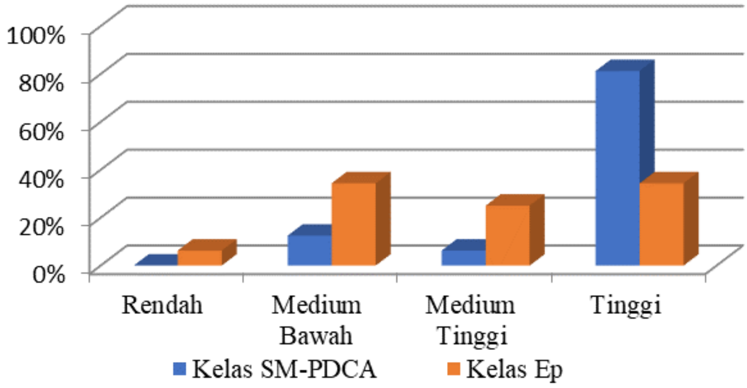

Figure 7. Comparison of the Percentage Distribution of N-Gain Cognitive Learning Outcomes for Class SM-PDCA and Class Ep

Based on Table 11 and Figure 7 it is known that the percentage of N-Gain distribution in the cognitive learning outcomes of SM-PDCA class students is in the high category of 81.25%, while the percentage of N-Gain distribution in Ep class students is in the high category of 34.375%. This clarifies the previous conclusion that there were more students whose cognitive learning outcomes increased significantly in the SM-PDCA class compared to the cognitive learning outcomes of Ep class students.

To determine the level of effectiveness of the SM-PDCA class and the Ep class in improving students' cognitive learning outcomes, the Cohen d-effect size and the mean N-Gain were calculated. The calculation results of the Cohen d-effect size and the average N-Gain can be seen in Table 12.

Table 12. Calculation results of Cohen's d-effect size and N-Gain Mean Data on Cognitive Learning Outcomes for SM-PDCA Class and Ep Class

	Kelas SM-PDCA		Kelas Ep	
	Result	**Conclusion**	**Result**	**Conclusion**
d-effect size Cohen	3,44	High or larger than normal	2,29	High or larger than normal
N-Gain Average	0,78	High	0,54	High

Table 12 shows that Cohen's d-effect size value of cognitive learning outcomes in both classes includes having high criteria or greater than usual, but the SM-PDCA class (d-effect size = 3.44) is higher than the Ep class (d-effect size=2,29). The mean N-Gain obtained by the SM-PDCA class was 0.78 including high, while the Ep class was 0.54 including above medium. Based on the calculation of Cohen's d-effect size and the average N-Gain obtained, learning with PDCA metacognitive strategies has higher effectiveness in improving students' cognitive learning outcomes than classes taught with expository strategies.

DISCUSSION

The relationship between metacognitive abilities and students' science process skills in acid and base solutions can be determined through a correlation test. The significance value obtained is used to obtain conclusions about the hypothesis. The results of the data analysis results on the correlation test can be seen in Table 13 and Table 14.

Table 13. Results of Data Analysis of the Relationship between Metacognitive Ability and Science Process Skills of Students in SM-PDCA Class

Variable	Correlation Test Type	Correlation coefficient	Significance Value	Conclusion	Correlation Level

Metacognitive abilities with science process skills	Spearman Correlation	0,050	0,785	H_{01} accepted (not related)	Very weak
Declarative knowledge with science process skills	Spearman Correlation	0,028	0,881	H_{02} accepted (not related)	Very weak
Procedural knowledge with science process skills	Spearman Correlation	-0,002	0,993	H_{03} accepted (not related)	Very weak
Conditional knowledge with science process skills	Spearman Correlation	-0,031	0,867	H_{04} accepted (not related)	Very weak
Metacognitive regulatory skills with science process skills	Spearman Correlation	0,057	0,756	H_{05} accepted (not related)	Very weak

Table 14. Results of Data Analysis of the Relationship between Metacognitive Ability and Science Process Skills of Students in Class Ep

Variable	**Correlation Test Type**	**Correlation coefficient**	**Significance Value**	**Conclusion**	**Correlation Level**
Metacognitive abilities with science process skills	*Product Moment Pearson*	-0,284	0,116	H_{01} accepted (not related)	Weak
Declarative knowledge with science process skills	*Product Moment Pearson*	-0,362	0,042	H_{02} accepted (not related)	Weak
Procedural knowledge with science process skills	*Product Moment Pearson*	-0,294	0,102	H_{03} accepted (related)	Weak
Conditional knowledge with science process skills	*Product Moment Pearson*	-0,304	0,091	H_{04} accepted (not related)	Weak
Metacognitive regulatory skills with science process skills	*Product Moment Pearson*	-0,230	0,206	H_{05} accepted (not related)	Weak

Table 13 and Table 14 show that the significance of the relationship between metacognitive abilities and the science process skills of SM-PDCA class students is 0.785, sig. > 0.05, and class Ep 0.116, sig. > 0.05, or H0 is accepted. Based on the significance, there is no correlation between metacognitive abilities and students' science process skills. This explains that the higher the students' metacognitive abilities, the higher the students' science process skills are not necessarily.

The relationship between metacognitive abilities and students' science process skills in acid and base solutions can be identified through a correlation test. The significance value obtained is used to obtain conclusions about the hypothesis. The value of the correlation coefficient that has been obtained, then interpreted the level of the relationship. The results of data analysis on the correlation test can be seen in Table 15 and Table 16.

Table 15. Results of Data Analysis of the Relationship between Metacognitive Abilities and Cognitive Learning Outcomes of Students in SM-PDCA Class

Variable	Correlation Test Type	Correlation coefficient	Significance Value	Conclusion	Correlation Level
Metacognitive abilities with science process skills	Spearman Correlation	0,070	0,704	H_{01} accepted (not related)	Very weak
Declarative knowledge with science process skills	Spearman Correlation	0,045	0,807	H_{02} accepted (not related)	Very weak
Procedural knowledge with science process skills	Spearman Correlation	0,043	0,813	H_{03} accepted (not related)	Very weak
Conditional knowledge with science process skills	Spearman Correlation	-0,055	0,763	H_{04} accepted (not related)	Very weak
Metacognitive regulatory skills with science process skills	Spearman Correlation	0,087	0,634	H_{05} accepted (not related)	Very weak

Table 16. Results of Data Analysis of the Relationship between Metacognitive Ability and Cognitive Learning Outcomes of Students in Class Ep

Variable	Correlation Test Type	Correlation coefficient	Significance Value	Conclusion	Correlation Level
Metacognitive abilities with science process skills	Spearman Correlation	-0,201	0,217	H_{01} accepted (not related)	Weak
Declarative knowledge with science process skills	Spearman Correlation	-0,362	0,042	H_{02} rejected (Related)	Weak
Procedural knowledge with science process skills	Spearman Correlation	-0,166	0,365	H_{03} accepted (not related)	Very Weak
Conditional knowledge with science process skills	Spearman Correlation	-0,234	0,197	H_{04} accepted (not related)	Weak
Metacognitive regulatory skills with science process skills	Spearman Correlation	-0,143	0,434	H_{05} accepted (not related)	Very Weak

Based on Table 15 and Table 16 it is explained that the significance of the relationship between metacognitive abilities and cognitive learning outcomes of SM-PDCA class students is 0.704, sig. > 0.05 and class Ep of 0.217, sig. > 0.05, or H0 is accepted. Based on the significance, there is no relationship between metacognitive abilities and cognitive learning outcomes of students. This proves that the higher the students' metacognitive abilities, the higher the students' cognitive learning outcomes are not necessarily.

The relationship between science process skills and students' cognitive learning outcomes in acid and base solutions can be identified through correlation tests. The significance value obtained is used to obtain conclusions about the hypothesis. The value of the correlation coefficient that has been obtained, then interpreted the level of the relationship. The results of data analysis on the correlation test can be seen in Table 17.

Table 17. Results of Data Analysis of the Relationship between Science Process Skills and Cognitive Learning Outcomes of Students in SM-PDCA Class and Ep Class

Variable	Correlation Test Type	Correlation coefficient	Significance Value	Conclusion	Correlation Level
Science process skills with cognitive learning outcomes of SMP-PDCA classes	Spearman Correlation	0,734	0,000	H_{01} rejected (Related)	Strong
Science process skills with cognitive learning outcomes Ep class	Spearman Correlation	0,707	0,000	H_{02} rejected (Related)	Strong

Based on table 17 shows that the significance value of the relationship between science process skills and cognitive learning outcomes of students, both SM-PDCA class and Ep class is worth 0.000, sig. < 0.05, then H0 is rejected. Based on the significance value, there is a correlation between science process skills and students' cognitive learning outcomes. This shows that the higher the students' science process skills, the higher the cognitive learning outcomes of students in SM-PDCA class or Ep class.

CONCLUSION

Based on the results of the analysis and discussion that have been described, it can be concluded that;

1. The implementation of the learning process in the SM-PDCA experimental class and the Ep control class has a very good category. The average implementation of the learning process in the SM-PDCA class was 96.97% and the Ep class was 97.61%;
2. Metacognitive abilities in the SM-PDCA experimental class and the Ep control class, the number of students in the SM-PDCA experimental class was in the low category of 9.375%, medium of 62.5%, and high of 28.125%. While the number of Ep class students in the low category was 9.375%, medium was 84.375%, and high was 6.25%. There are as many students who have low category metacognitive knowledge in the Ep class as the SM-PDCA class, but fewer students who have high category metacognitive knowledge than the SM-PDCA class. Meanwhile, there were more students who had medium category metacognitive knowledge in the Ep class than the SM-PDCA class;
3. Science process skills in the SM-PDCA experimental class with a very low category of 3.125%, low of 6.25%, medium of 21.875%, high of 34.375%, very high of 34.375% and Ep control class with a very low category of 6, 25%, low 9.375%, moderate 43.75%, high 34.375%, very high 6.25%;
4. Cognitive learning outcomes in the SM-PDCA experimental class had an average pretest of 50.48 with a minimum score of 30.77 and a maximum of 69.23, an average posttest of 88.22 with a minimum score of 53.85 and a maximum of 100.00 and control class Ep has an average pretest of 50.00 with a minimum score of 15.38 and a maximum of 76.92, an average posttest of 77.64 with a minimum score of 53.85 and a maximum of 100.00;

5. The PDCA metacognitive learning strategy has an influence on the metacognitive abilities of students which can be seen based on the differences in metacognitive abilities both as a whole and for each category between the students in the SM-PDCA experiment class compared to the Ep control class students and the average score of metacognitive abilities (declarative knowledge, procedural knowledge, conditional knowledge, and metacognitive regulatory skills) of students taught with the PDCA metacognitive learning strategy (72.74) higher than the control class Ep (66.95);
6. The PDCA metacognitive learning strategy has an influence on students' science process skills which can be seen based on the differences in science process skills between students in the SM-PDCA experiment class and students in the control class Ep, the average score of students' science process skills taught by learning strategies metacognitive PDCA (81.43) is higher than expository learning strategies (75.99), and PDCA metacognitive learning strategies are more effective in improving science process skills than expository learning strategies with d-effect size Cohen and N-Gain respectively of 3.22 and 0.69 in the SM-PDCA experimental class and 3.14 and 0.58 in the Ep control class;
7. The PDCA metacognitive learning strategy has an influence on students' cognitive learning outcomes which can be seen based on the differences in cognitive learning outcomes between students in the SM-PDCA experiment class and students in the control class Ep, the average score of cognitive learning outcomes of students who are taught with learning strategies metacognitive PDCA (88.22) is higher than expository learning strategies (77.64), and PDCA metacognitive learning strategies are more effective in improving science process skills than expository learning strategies with d-effect size Cohen and N-Gain respectively of 3.44 and 0.78 in the SM-PDCA experimental class and 2.29 and 0.54 in the Ep control class;
8. There is no relationship between metacognitive abilities and students' science process skills, both as a whole and for each category in metacognitive abilities;
9. There is no relationship between metacognitive abilities and cognitive learning outcomes of students, both as a whole and for each category in metacognitive abilities;
10. There is a strong relationship between science process skills and students' cognitive learning outcomes, both in the SM-PDCA experimental class and the Ep control class.

REFERENCES

1. Agustina, P., Saputra, A., Clara, A. Y. (2018). Hubungan Keterampilan Proses Sains dengan Hasil Belajar Mahasiswa Calon Guru Biologi pada Matakuliah Praktikum Anatomi Hewan Tahun Akademik 2017/2018. *Prosiding Seminar Nasional Pendidikan Sains*, 66-73.
2. Cetin-dindar, A., & Geban, O. (2016). Conceptual Understanding of Acids and Bases Concepts and Motivation to Learn Chemistry, *Journal of Chemical Education*, 0671 (September), 14.
3. Cook, E., Kennedy, E., & Mcguire, S. Y. (2013). Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses. *Journal of Chemical Education*, 90(2), 961–967.
4. Fadiawati, N. 2011. Perkembangan Konsepsi Pembelajaran Tentang Struktur Atom dari SMA hingga Perguruan Tinggi. *Disertasi*. SPs-UPI. Bandung.
5. Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64–74. https://doi.org/10.1119/1.1880
6. Hartman, H. J. 2011. *Metakognisi dalam Pembelajaran dan Pengajaran, Teori, Penelitian, dan Praktik*. Hilldale, NJ: Lawrence Erlbaum Associates, Inc.

7. Iqbalia, Farhana. 2015. Analisis Keterampilan Proses Sains Siswa pada Model Pembelajaran Predict, Observe, Explain (POE) pada Materi Asam Basa. Skripsi Tidak Diterbitkan. UIN Jakarta.
8. Jaunhangeer, S., Shuib, L., & Hasan, Z. A. (2019). Metacognitive Skilfulness of Students in Problem Solving. *International Journal of Information System and Engineering*, 6(2), 1–9.
9. Kementerian Pendidikan dan Kebudayaan. 2017. *Model Silabus Mata Pelajaran Sekolah Menengah Atas/Madrasah Aliyah (SMA/MA)*. Jakarta: Kemendikbud.
10. Muhali. 2015. Meningkatkan Kesadaran Metakognisi melalui Strategi Pembelajaran Metakognisi pada Pembelajaran Kimia di Sekolah Menengah. *Prosiding Seminar Nasional Pendidikan Sains.* Universitas Negeri Surabaya, 24 Januari 2015.
11. Mulyasa, E. 2011. *Manajemen Pendidikan Karakter*. Jakarta: Bumi Aksara.
12. Nuryana, E., & Sugiarto, B. (2012). Hubungan Keterampilan Metakognisi Dengan Hasil Belajar Siswa Pada Materi Reaksi Reduksi Oksidasi (Redoks) Kelas X-1 Sma Negeri 3 Sidoarjo. *Unesa Journal of Chemical Education*, 2003(1), 83–91.
13. Parlan, P., Ibnu, S., Suharti, S. (2018). Effects of the Metacognitive Learning Strategy on the Quality of Prospective Chemistry Teacher's Scientific Explanations. *International Journal of Instruction*, 11(4), 673–688.
14. Rompayom, P., Tambunchong, C., Wongyounoi, S., & Dechsri, P. (2010). The Development of Metacognitive Inventory to Measure Students' Metacognitive Knowledge Related to Chemical Bonding Conceptions, (Iaea), 1–7.
15. Schraw, G., & Dennison, R. S. (1994). *Assessing metacognitive awareness. Contemporary Educational Psychology*. https://doi.org/10.1006/ceps.1994.1033
16. Sugiyono. 2017. *Statistika Untuk Penelitian*. Bandung: Alfabeta.
17. Tosun, C., & Senocak, E. (2013). The Effects of Problem-Based Learning on Metacognitive Awareness and Attitudes toward Chemistry of Prospective Teachers with Different Academic Backgrounds. *Australian Journal of Teacher Education*, 38(3).
18. Triwiyanto, T. 2014. Pengantar Pendidikan. Jakarta: Bumi Aksara.
19. Wahyudi, A., Marjono, Harlita. 2015. Pengaruh Problem Based Learning terhadap Keterampilan Proses Sains dan Hasil Belajar Biologi Siswa Kelas X SMA Negeri Jumapolo Tahun Pelajaran 2013/2014. *Bio-Pedagogi*, 4(1): 5-11.
20. Ware, K., & Rohaeti, E. 2018. Penerapan Model Problem Based Learning dalam Meningkatkan Kemampuan Berpikir Analitis dan Keterampilan Proses Sains Peserta Didik SMA. *Jurnal Tadris Kimiya*, 3(1), 42-51.
21. Wibowo. 2007. *Manajemen Kinerja*. Jakarta: PT. Raja Grafindo Persada.
22. Young, A., & Fry, J. D. (2008). 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
23. Zulaihah, Binti. 2019. Pengaruh Strategi Pembelajaran Metakognitif Preparing, Doing, Checking, dan Assessing and Following-Up (PDCA) terhadap Pengetahuan Metakognitif dan Prestasi Belajar Siswa Peserta Didik Kelas X MIPA SMAN 1 Turen pada Materi Larutan Elektrolit dan Nonelektrolit. Skripsi Tidak Diterbitkan. Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Negeri Malang.