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THE EFFECT OF PROBLEM-BASED LEARNING ON STUDENTS' PROBLEM-SOLVING AND SELF-LEARNING ABILITIES IN ACID-BASE

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Abstract – This study aimed to determine students' problem-solving and independent learning on acid-base and involved 30 students of class XI MIA SMA Negeri 4 Maluku Tengah. The students were divided into two classes (experimental and control groups), and the chemistry teaching was conducted online because of the Covid-19 pandemic. Data were collected using problem-solving tests and self-learning ability questionnaires. The results showed that the experimental group (problem-based learning class) had better problem-solving and independent learning abilities than the control group (conventional method class). This result implies that problem-based learning improved students' problem-solving abilities and helped them provide appropriate solutions. Problem-based learning also helps students to learn more independently.

Keywords: *Problem-based learning, problem-solving, self-regulated, online learning.*

INTRODUCTION

Chemistry is a challenging subject for today's teachers. Chemistry teachers have the critical task of ensuring students develop the necessary learning skills. Learning could be ineffective if teachers do not understand the needs of their students (Davis et al., 2006). Therefore, they must determine students' needs, interests, and motivation (Valdez & Bungihan, 2019). Teachers need to choose a learning model allowing students to be responsible learners. Chemistry learning should bring real-world situations into the classroom, solve problems, and encourage students to connect their knowledge and application in everyday life. Students actively build their knowledge and meaning based on their experiences with environmental problems. Students are expected to understand abstract concepts in chemistry more quickly with this learning. Students not only memorise concepts but can understand them well through scientific processes and apply them in everyday life.

The two-year pandemic has forced a transformation of learning from face-to-face to online learning. The lack of students' face-to-face interaction with teachers in online learning puts students into learning difficulty. Some teachers also find it difficult to bring the real world into learning, guiding students to solve problems and encouraging students to connect their knowledge with everyday contexts. Problem-based learning (PBL) can encourage active learning, support knowledge construction, and naturally integrate school and real-life learning. In PBL, students are guided to solve a problem in everyday life through a series of scientific processes as a driving force for students to learn. As a result, students get authentic experiences that encourage active learning, support knowledge construction, and naturally integrate school and real-life learning (Reigeluth et al., 2017).

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There are four principles of problem-based learning proposed by Reigeluth (2017): the problem chosen is a problem that is authentic, current, fits the material, and allows for many possible problem-solving solutions to emerge. The teacher's role in learning is to support students in developing metacognitive abilities and problem-solving skills. The authentic assessment is used to validate the learning objectives. The steps in the PBL approach include introducing problems, inquiry, learning self-regulation, submitting hypotheses, and evaluating work results (Arends, 2012). With problem-based learning, students develop at their own pace and use technology to obtain the necessary information, supporting independent learning. Students are required to prepare a plan to provide solutions.

The review provided by Sulistiyani et al., (2022) found that PBL is a potential approach for effective online learning. PBL has improved student achievement (Wonda et al., 2016). Implementing PBL and green chemistry-based Study History Sheet (SHS) improves students' understanding of solubility (Subandi et al., 2017). Furthermore, problem-based learning is believed to increase students' problem-solving abilities (Cheng et al., 2018; Tawfik & Lilly, 2015; Valdez & Bungihan, 2019). Students will also acquire skills that will assist them in their interactions with the dynamic community or society where they live (Havenga & Van Wyk, 2017; Tsai et al., 2015; Ying, 2003; Zhang, 2002). In addition, with online learning, students will try to learn independently (Nasser & Mulhim, 2021; Tawfik & Lilly, 2015; Vos et al., 2016).

METHOD

This study involved two group of students of SMA Negeri 4 Maluku Tengah. The experimental class was taught using problem-based online learning, while the control class was conventional. Both classes were carried out online. The PBL applied the syntax proposed by Arends (2012). Learning begins with giving the main problem and then guides students to plan independent learning. Students' problem-solving ability was investigated using the problem ability test, while students' independent learning used a questionnaire. The problem-solving ability is measured based on the 4-level solving rubric from Patrick et al. (2016), like the following. The level of students' problem-solving was categorized according to the procedure in Table 1. Level 4, the solution and all relevant work are correct, or there was an error due to some minor computation or copying error. Level 3, students choose the right procedure/strategy to solve this problem; however, the response/solution is not entirely correct. Level 2, students choose the right procedure/strategy to solve this problem; however, the response/solution is incorrect. Level 1, incomplete and/or incorrect answers/solutions are given as evidence of efforts to solve the problem: level 0, no answer, empty.

Table 1. Problem Solving Ability Level (Valdez & Bungihan, 2019)

Description	Range Level
Very Low	0 – 0.49
Low	0.50 – 1.49
Average	1.50 – 2.49
High	2.50 – 3.49
Very High	3.50 – 4.00

The ability to learn independently is obtained from a questionnaire with the following indicators: independence, confidence, discipline, initiative, and self-control (Hidayati & Listyani, 2007). Next, it is classified based on the procedure from Riduwan (2009), as shown in Table 2.

Table 2. The interpretation of the independence level of students (Riduwan, 2009)

Description	Range Level
Very Low	0 – 20
Low	21 – 40
Average	41 – 60
High	61 – 80
Very High	81 – 100

Analysis of variance was also employed to determine the effect of problem-based learning on problem-solving and independent learning abilities.

RESULT AND DISCUSSION

A chemistry question related to real-life situations investigated students' problem-solving abilities. The results of students' problem-solving abilities are presented in Table 3.

Table 3. Description of Students' Problem-Solving Abilities

Question	Experimental Group			Control Group		
	Mean	SD	Category	Mean	SD	Category
1	1.80	1.15	Average	0.87	0.83	Low
2	2.13	0.74	Average	1.40	0.83	Low
3	2.20	1.01	High	1.60	0.83	Average
4	2.60	0.74	High	1.60	1.30	Average
5	2.33	0.82	Average	1.47	0.74	Low
6	1.87	0.99	Average	0.80	0.77	Low
7	2.33	0.98	Average	1.47	0.74	Low
8	2.40	0.91	Average	1.80	0.94	Average
9	2.47	0.83	Average	1.40	1.06	Low
10	2.07	1.22	Average	1.33	1.05	Low
Total	2.22	0.22	Average	1. 35	0.30	Low

The levels of student's independent learning are presented in Table 4.

Table 4. Students' Independence Level

Indicator	Experimental Group			Control Group		
	Score	%	Category	Score	%	Category
1	3.23	80.75	Very High	2.40	60.00	Average
2	3.21	80.25	Very High	2.26	56.50	Average
3	3.21	80.25	Very High	2.63	65.75	high
4	3.24	81.00	Very High	2.29	57.33	Average
5	3.20	80.00	High	2.32	58.00	Average
6	3.2	81.00	Very High	2.58	64.50	high
Total	3.22	80.54	Very High	2.41	69.25	Average

Students in the experimental and control classes were given the same questions. The evaluation of student responses showed that students' problem-solving abilities with PBL were better than students in conventional classes. This result shows that the intervention positively impacts students' ability to build and improve their problem-solving skills. This finding supports the conclusion of Dochy et al. (2003) that students who are taught using PBL can develop immediate

and long-term problem-solving skills. PBL improves students' abilities and helps them see the relationship between concepts when they learn facts and abilities by actively working on knowledge rather than passively receiving it. Furthermore, there is evidence that PBL enhances self-directed learning and promotes thinking and problem-solving skills.

In table 3, students with PBL learning demonstrate higher independence levels than those with conventional methods. According to Reigeluth (2017), students who can learn independently will control their learning methods more effectively and can develop their self-regulation abilities. This phenomenon shows that the intervention positively impacts students' ability to build and improve their problem-solving skills. This finding supports the conclusion of Dochy et al. (2003) that students with PBL can develop immediate and long-term problem-solving skills. Furthermore, there is evidence that PBL enhances self-directed learning and promotes thinking and problem-solving skills. Significant differences in students' problem-solving and independent learning abilities in PBL and conventional classes were determined using a multivariate analysis of variance (Manova). The results of Manova shown the value > 0.05 and significance < 0.05; thus, it can be concluded that the online PBL learning model affects students' problem solving and independent learning abilities. It can also be seen that there are differences in students' problem-solving and independent learning abilities due to the influence of the learning model, which is indicated by a significance value smaller than 0.05. The learning environment can cause this phenomenon, student characteristics, behaviour, readiness, and duration of program implementation (Albanese, 2000).

CONCLUSION

The results of this study indicate that the PBL strategy increased students' problem-solving abilities and learning independence. Students in the PBL class have better problem-solving skills than students in the conventional class.

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