

Implementation of Electronic Worksheets Based on Problem-based Learning on Acid-Base Materials to Develop Students' Problem-solving Ability

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Abstract: Learning during a pandemic requires teachers to innovate in developing teaching materials that can be used in online learning. The use of problem-based learning-based electronic student worksheets (SW) can be an innovative solution for teaching materials that are integrated with technological developments that can help the online learning process. This study aims to analyze the differences in students' problem-solving abilities between classes that use problem-based learning-based electronic student worksheets and classes that do not use problem-based learning-based electronic student worksheets on acid-base materials and analyze the effective contribution of the application of problem-based electronic worksheets. -based learning on students' problem-solving abilities on acid-base material. This research is a Quasi Experiment research type with post-test only control-group type. The research instruments used are syllabus, lesson plans, problem-based learning-based electronic worksheets and problem-solving skills. The data analysis technique in this study consisted of 2 analyzes, namely the independent sample t-test and effect size analysis. The results of the development research show that: (1) there are differences in the problem-solving abilities of students between classes that use problem-based learning-based electronic student worksheets and those that do not use problem-based learning-based electronic student worksheets on acid-base materials for class XI MIPA, (2) Problem-based learning-based electronic worksheets provide an effective contribution to students' problem-solving abilities on acid-base materials with a percentage of 2.5%.

Keywords: Acid-base; Electronic student worksheet; Problem-based learning; Problem-solving abilities

Introduction

Improving the quality and potential possessed by students is an effort carried out in educational activities. It is important to do this continuously in improving and developing the quality of students, especially in the 21st century today. Along with the times, students are required to have skills in accordance with the concept of 21st century learning for the future. The learning activities must ensure that students must have skills according to the concept of learning in the 21st century, namely critical thinking skills, problem solving, communication and collaboration, creativity and

innovation, technology and information skills, as well as life and career skills (Anazifa & Djukri, 2017).

Problem solving ability is one of the abilities that students must have in the 21st century today (Irwanto et al., 2018). Problem solving is a systematic process that utilizes the knowledge possessed by students to solve an existing problem (Hidayat et al., 2018). The ability to solve chemistry problems is one of the indicators of success in chemistry learning activities (Sulistyowati et al., 2012). However, the reality is that in Indonesia, the problem solving ability of students in chemistry is still low and there is a need for improvement (Istyadji et al., 2018). The difficulty of students in solving a chemistry problem is usually caused by a lack of knowledge about

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the subject matter, misunderstandings or misconceptions, and poor problem-solving strategies. So that educators need to explore learning that can develop students' chemical problem solving abilities (Yuriev et al., 2017).

The learning model that can be used to develop problem solving skills is a problem-based learning model (Valdez & Bungihan, 2019). Problem-based learning is a collaborative learning model that is centered on students by involving the knowledge and skills of students in solving a problem (Shultz & Li, 2016). Problem based learning aims to improve critical thinking skills, analyze daily life problems, work together in teams and communicate skills (Günter & Alpat, 2017). Learning with problem based learning is more effective than conventional learning to improve problem solving abilities and motivation of students in the learning process (Argaw et al., 2017). The problem-based learning model according to several research results shows the implementation of effective learning and is able to improve students' critical thinking skills and problem-solving abilities to the problems given (Aidoo et al., 2016)

The COVID-19 pandemic demands that the learning process in schools be carried out online and educators are required to innovate distance learning (Abidah et al., 2020). One of the innovations made is using SW which can be packaged innovatively in online form which is commonly called e-worksheet or electronic SW (Hidayah et al., 2020). electronic SW has an effect on the cognitive level of students to increase, besides that, the interest and motivation of students towards learning will increase (Lailiah & Wardani, 2021). Utilization of electronic SW for learning activities can be developed with a problem-based learning model (Hidayah et al., 2020).

High school chemistry subjects have several basic materials, one of which is acid-base material which is usually given at the beginning of the even semester of class XI. Acid-base material was used in this study because the material was perceived by some students as material that tends to be difficult to understand (Zuhroti, 2018). Sub-material contained in acid-base in addition to concepts, there is also a sub-material of calculations using chemical mathematical formulas. Students are required to be able to understand the learning material even in a state of the COVID-19 pandemic with online learning. This requires the role of educators to work harder to do interesting learning, so that students can more easily learn the subject matter (Hidayah et al., 2020)

Based on these problems, the application of online teaching materials in the form of problem-based learning-based electronic worksheets that can be used to develop students' problem solving skills in acid-base chemistry subjects for class XI SMA. This is based on

several research results, namely the electronic SW developed by Syafitri and Tressyalina (2021) which is very useful to help the learning process during the current pandemic. In addition, problem-based learning-based electronic worksheets were also developed by (Hidayah et al., 2020) effectively used as online teaching materials for students during the COVID-19 pandemic.

Method

This research is a quasi-experimental research (Quasi Experiment Design) with post-test only control-group type. This research was conducted at SMA Negeri 1 Bumiayu, Brebes Regency on January 4 - February 8, 2022. Sampling used a cluster random sampling technique and obtained two classes, namely the experimental class and the control class with the number of samples used consisting of 72 students. The experimental class is a class that uses electronic worksheets based on problem-based learning on acid-base materials, while the control class is a class that does not use these media in the learning process. However, both classes received the same portion of acid-base material, then were given post-test treatment about problem-solving abilities to determine the effect of the treatment carried out.

Table 1. Research Design

Group	Treatment	Post-test
Experiment	X	Y
Control	-	Y

Information:

X : Treatment using electronic worksheets based on problem-based learning on acid-base materials

Y : Problem solving ability test

The research instruments used are syllabus, lesson plans, problem-based learning-based electronic worksheets and problem-solving skills. The data analysis technique in this study consisted of 2 analyzes, first using the independent sample t-test which was used to analyze whether there were differences in students' problem-solving abilities between classes that used problem-based learning-based electronic worksheets and classes that did not use electronic SW problem-based learning on acid-base materials. Calculation of independent sample t-test can use the Formula 1.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \tag{1}$$

Information:

\bar{X}_1 : Sample mean 1

\bar{X}_2 : Sample mean 2

S_1^2 : Sample variance 1

S_2^2 : Sample variance 2

The second data analysis technique uses effect size analysis to analyze the percentage contribution of problem-based learning-based electronic worksheets to students' problem-solving abilities on acid-base material. The calculation of the effect size value can be done using the Formula 2.

$$\delta = \frac{Y_e - Y_c}{S_c} \tag{2}$$

Information:

- δ : Effect size
- Y_e : Experimental group mean
- Y_c : Average of comparison group
- S_c : Standard deviation of the comparison group

Furthermore, the results of the calculation of the effect size will be interpreted into the Cohen scale in Table 2 as follows:

Table 2. Classification of Effect Size

Effect Size	Cohen's Standard
Effect Size 0.00 – 0.20	Small
Effect Size 0.21 – 0.50	Medium
Effect Size 0.51 – 0.80	Large

The percentage contribution of problem-based learning-based electronic worksheets to students' problem-solving abilities on acid-base material can be obtained using effect size analysis with the help of SPSS IBM 22. The results of the effect size analysis are then seen by the partial eta squared value contained in the effect size result table, then the value of the effect size multiplied by 100 percent to determine the percentage of the effective contribution of the application of problem-based learning-based electronic worksheets to the problem-solving abilities of students on acid-base materials.

Results and Discussion

This study aims to analyze the effectiveness of problem-based learning-based electronic worksheets on students' problem-solving abilities on acid-base materials. The research, which was conducted in class XI at SMA Negeri 1 Bumiayu, involved two classes as the experimental class and the control class. The experimental class, namely class XI MIPA 1, is a class that applies problem-based learning-based electronic SW assisted learning. While the control class, namely class XI MIPA 2 is a class that applies learning that is usually applied in schools using conventional learning. Both classes were given the same portion regarding acid-base material and at the last meeting an evaluation was carried out to measure the problem-solving abilities of students on acid-base material.

Table 3. Problem Solving Ability Test Results

Description	Class	
	Experiment	Control
Number of Students	36.0	36.0
Average value	79.2	75.8
The highest score	98.0	96.0
Lowest Value	54.0	48.0

Based on Table 3, it can be seen that the average problem-solving ability of experimental class students who use problem-based learning-based electronic worksheets on acid-base materials is 79.2. While the average value of the problem solving ability of the control class students is 75.8. Based on the results of the average value of the two classes, it can be seen that the experimental class has a higher average value of problem solving ability than the control class with a difference of 3.4. Furthermore, to analyze the effectiveness of problem-based learning-based electronic worksheets on students' problem-solving abilities, analysis of research data was carried out using independent sample t-test and effect size analysis.

Normality test

Table 4. Normality Test Results

Class	Sig. Shapiro Wilk	Information
Experiment	0.636	Normal
Control	0.513	Normal

Significance level: 0.05

Based on Table 4, the results of the normality test of students' problem-solving ability values in the experimental class and control class showed a significance value of more than 0.05, so that the sample data came from a normally distributed population, namely 0.636 for the experimental class and 0.513 for the control class, respectively.

Homogeneity Test

Table 5. Homogeneity Test Results

Value of Problem Solving Ability	
Levene statistics	: 0.114
Sig.	: 0.737
Level of significance	: 0.05

Based on Table 5, the results of the homogeneity test on the problem-solving ability of students in the experimental class and control class show that the significance value is more than 0.05 so that the sample data for both classes come from the same population variance.

Boxplot Test

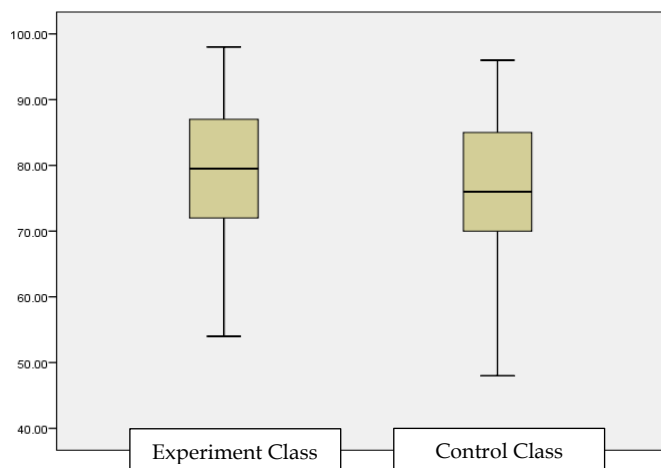


Figure 1. Boxplot Test Results

Based on the results of the boxplot test, it shows that the boxplot of the problem-solving ability scores of students in the experimental class and control class does not have a point outside the box, so it can be concluded that there are no univariate outliers.

The first hypothesis testing was conducted to analyze whether there were differences in problem solving abilities between students in the experimental class and the control class. Data analysis was conducted using independent sample t-test with the help of SPSS IBM 22. The results of these tests in this study are presented in Table 6.

Table 6. Test Results Independent sample t-test

Variable Problem Solving Ability	
Sig. (2-tailed)	: 0.185
t	: 1.339
Level of significance	: 0.05

Based on Table 6, it shows that the significance value (2-tailed) > 0.05 means that there are differences in students' problem-solving abilities between classes that use problem-based learning-based electronic worksheets and classes that do not use these media. The significant difference in the problem-solving abilities of students between the experimental class and the control class could be due to the problem-based learning using electronic SW based learning. Experimental class students were trained in problem-solving skills according to the syntax of the problem-based learning model. This is in line with research conducted by Sukorini & Purnomo (2019), namely the use of practical problem-based learning-based teaching materials to train students' problem-solving skills in the learning process.

Learning activities using problem-based learning contain stages that stimulate students to determine a problem and think about solutions to these problems.

Problem-based learning usually begins with identifying problems related to certain phenomena, then identifying several questions relevant to learning by each group, after which students must be able to provide solutions or answers to each question given (Jansson et al., 2015). In addition, the learning activities contained in the electronic SW also contain activities that can train students' problem-solving skills. The stages of problem-based learning help students in solving a problem by stages of understanding the problem, gathering information to answer questions, planning solutions, solving problems according to plan and re-examining the results of the completion.

The application of electronic SW in chemistry learning has several advantages, namely (1) creating an active classroom atmosphere because students are directly involved in learning activities, (2) can improve student learning outcomes because they can access media flexibly, (3) participants students can learn independently because they have access to media to explore whenever and wherever, (4) facilitate students' problem solving through discussion (Sya'idah et al., 2020). In addition, learning on acid-base material with problem-based learning is also considered effective for improving students' problem-solving abilities (Jundu et al., 2018). This is in line with research conducted by Veldez & Bungihan (2019), namely learning using problem-based learning can improve students' problem-solving abilities, according to the results of the analysis that there are significant differences in the problem-solving abilities of students in problem-based learning classes and it is proven effective use in learning chemistry in the Philippines.

The second hypothesis testing was conducted to analyze what percentage of the effective contribution of the application of problem-based learning-based electronic worksheets to students' problem-solving abilities on acid-base material. The data analysis carried out was an effect size test with the help of SPSS IBM 22. The results of the effect size analysis for students' problem solving abilities are presented in Table 7.

Table 7. Effect Size Analysis Results

Variable	Effect Size	Percentage	Category
Problem solving	0.025	2.5%	Small skill

Based on Table 6, the results of the effect size analysis to determine the effective contribution of the application of the electronic SW to the improvement of students' problem-solving abilities are 0.025 or 2.5%. These results indicate that the contribution of the application of problem-based learning-based electronic worksheets to students' problem-solving abilities on acid-base materials is categorized as small.

The contribution of the application of problem-based learning-based electronic worksheets shows little results, which can be caused by the fact that students have never previously measured problem-solving abilities in chemistry subjects. Another thing that causes a small contribution is also because the online learning process is considered less than optimal in teaching and learning activities (Hidayat et al., 2020). Previous research conducted by Apriliasari et al. (2019) also shows the same thing, namely problem-based learning-based learning media can improve students' problem-solving abilities and contribute to problem-solving abilities by 0.06 or 6% in the small category.

Electronic SW is one of the media that can support online learning and affect student learning outcomes in aspects of knowledge, skills, and attitudes (Sha'idah et al., 2020). However, a survey conducted by Serene et al. (2011) shows that the factor that greatly influences the learning process and student learning outcomes in applying the problem based learning model is the chemistry educator who guides the learning process. Good problem-solving skills must be supported by a good understanding of concepts, the use of problem-based learning in accordance with the 2013 curriculum can improve students' problem-solving abilities on acid-base material (Jundu et al., 2018).

Conclusion

Based on the results of the study it can be concluded that there are differences in students' problem-solving abilities between classes that use problem-based learning-based electronic worksheets and classes that do not use problem-based learning-based electronic worksheets on acid-base materials for class XI MIPA. The problem-based learning-based electronic SW provides an effective contribution to students' problem-solving abilities on acid-base material with a percentage of 2.5%.

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