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The Effectiveness of Learning Models *Problem Solving* on Electrolyte and Nonelectrolyte Solutions to Improve Science Process Skills

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Abstract: The effectiveness of Problem Solving Learning Models on Electrolyte and Non Electrolyte Solution Materials in Improving Sains Process Skills. *The purpose of this research was to describe the effectiveness of a problem solving learning model on electrolyte and non electrolyte solution material. The method used was a quasi-experiment with the matching only pretest-posttest control group design. The population on this research was all of the students from Senior High School Al-Azhar 3 Bandar Lampung in grade X IPA. The research sample was determined by purposive sampling technique, in order to obtain class X IPA 4 as the experimental class and X IPA 3 as the control class. The data analysis technique used is the difference test of two means using the t-test. The results showed that the n-gain mean of science process skills in the experimental class (0.67) was in the medium category; There is a significant difference in the average posttest score of science process skills between the experimental class and the control class. Thus, it can be concluded that the problem solving learning model on electrolyte and non-electrolyte solution material is effective for increasing students' science process skills.*

Keywords: *electrolyte and non-electrolyte solutions, science process skills, problem solving learning models.*

Abstrak: Keefektifan model pembelajaran problem solving pada materi larutan elektrolit dan nonelektrolit untuk meningkatkan keterampilan proses sains. Penelitian ini bertujuan untuk mendeskripsikan keefektifan model pembelajaran problem solving pada larutan elektrolit dan nonelektrolit untuk meningkatkan keterampilan proses sains. Metode penelitian yang digunakan adalah kuasi eksperimen dengan desain The Matching-Only Prettest-Posttest Control Group design. Populasi dalam penelitian ini adalah seluruh siswa kelas X IPA SMA Al-Azhar 3 Bandar Lampung. Sampel penelitian ini ditentukan dengan teknik purposive sampling, sehingga diperoleh kelas X IPA 4 sebagai kelas eksperimen dan X IPA 3 sebagai kelas kontrol. Teknik analisis data yang digunakan adalah uji beda dua rata-rata dengan menggunakan uji t-. Hasil penelitian menunjukkan bahwa rata-rata n-gain keterampilan proses sains pada kelas eksperimen (0,67) berada pada kategori sedang; terdapat perbedaan yang signifikan rata-rata skor posttest keterampilan proses sains antara kelas eksperimen dan kelas kontrol. Dengan demikian dapat disimpulkan bahwa model pembelajaran problem solving pada larutan elektrolit dan nonelektrolit efektif untuk meningkatkan keterampilan proses sains siswa.

Kata kunci: Larutan elektrolit dan nonelektrolit, keterampilan proses sains, model pembelajaran pemecahan masalah

- **INTRODUCTION**

Chemistry studies everything about matter, which includes composition, structure, properties, changes, dynamics, and energetics of substances that involve skills and reasoning (BNSP, 2006; Fadiawati, 2011; Paulina & Permana, 2018) . There are three things related to the characteristics of chemistry, namely chemistry as a product in the form of facts, concepts, principles, laws, and theories; chemistry as a scientific process or work; and chemistry as an attitude (Anggraini, Fadiawati & Diawati, 2012; Etikasari, Rosilawati & Tania, 2015). Therefore, in studying chemistry, we do not only pay attention to chemistry as a product, but also as a process to discover the science (Mudalara, 2012).

Science process skills (KPS) need to be trained and developed in the learning process, because they can help students learn to develop their minds, provide opportunities for students to make discoveries, provide intrinsic satisfaction if students succeed in finding something and help students learn science concepts (Trianto, 2010).). KPS is a directed scientific skill (both cognitive, affective, and psychomotor) that can be used to find a concept, principle, or theory to develop a pre-existing concept (Indrawati, 1999).

In chemistry learning, one of the KDs listed in the 2013 curriculum that must be mastered by even semester X graders is KD 3.8, which is analyzing the properties of electrolyte and non-electrolyte solutions based on their electrical conductivity, and KD 4.8, namely designing, conducting, and concluding and presenting experimental results to determine the nature of electrolyte solutions and non-electrolyte solutions.

This KD in learning begins with the stages of designing an experiment, taking, processing and interpreting data, as well as conveying the results of the experiment orally and in writing. This stage is in accordance with thelearning model *problem solving*, namely: formulate problems, seek information, formulate hypotheses, collect data, analyze data and conclude. Learning withmodels *problem solving* can increase learning activities and achievements which include student competencies, knowledge, attitudes, and skills (Carolin, Saputro & Nugroho, 2015).

The first step of thelearning model *problem solving* is given a discourse or problem regarding the difference in electrical conductivity between dilute and concentrated solutions in electrolyte and non-electrolyte solutions. Then students are asked to make a problem formulation by asking questions related to the problem, so that in this step the KPS that is trained is the skill of asking questions. After that, students look for as much information as possible from various relevant sources to solve the problems found. Next, students formulate hypotheses after getting information, so that in this step the skills that are trained are the skills of hypothesizing. Then to test the truth of the hypothesis that has been made, students collect data by conducting experiments on the difference in electrical conductivity between aqueous and concentrated solutions in electrolyte and non-electrolyte solutions, so that at this stage the KPS trained are skills in using tools or materials and carrying out experiments. The data obtained from the experimental results were analyzed by answering questions that guided students to build concepts. Students relate the results obtained during the experiment with various previous sources, so that at this stage the KPS being trained is the skill of applying concepts. The last step is that students draw conclusions from the knowledge obtained based on the data that has been analyzed.

The results of previous research on learning withmodels *problem solving* show thatlearning models *problem solving* can improve KPS and academic achievement (Aka, Guven & Aydogdu, 2010), improve classification skills on acid-base materials (Sherliani, Kadaritna & Efkar, 2017), improve KPS students on salt hydrolysis material (Hartini, Kusasi & Irani, 2017), improve grouping and conclusion skills on acid-base material (Novratilova, Kadaritna & Tania, 2015), improve students' KPS (Ubaidillah, 2016; Kadaritna, 2014). improve inference and communication skills on buffer solution material (Putri, Rudibyani & Efkar, 2015).

However, the facts that occur in the field, in the process of learning chemistry in schools still use conventional and theoretical learning (Alfiriani, 2017; Ardian, 2015). Learning does not emphasize the process aspect so that students' KPS is less developed (Fitriyani, Haryani, & Susatyo, 2017). Another fact obtained from the results of observations and interviews with chemistry subject teachers in class X SMA Al-Azhar 3 Bandarlampung, learning chemistry has referred to the 2013 curriculum, but the learning process is still using conventional learning. The chemistry learning process in the classroom is more teacher-centered, dominant learning uses the lecture method; occasional discussion and demonstration.

Based on this description, this article describes the effectiveness oflearning models *problem solving* on electrolyte and non-electrolyte solutions to improve science process skills.

- **METHOD**

The population in this study were all students of class X IPA SMA Al-Azhar 3 Bandarlampung for the Academic Year 2019/2020 spread over six classes. The sample of this research are two classes of the six classes. Sampling was carried out by *purposive sampling technique,* determined by class X IPA 3 and X IPA 4 as the research sample, obtained X IPA 3 as an experimental class usinglearning models *problem solving* and X IPA 4 as a control class using conventional learning.

The method used in this research is themethod *Quasi Experiment* using *The Matching-Only Pretest-Posttest Control Group design* (Fraenkel, Wallen & Hyun, 2012).

The independent variables in this study were thelearning model *problem solving* in the experimental class and the conventional learning model in the control class. The dependent variable is the students' science process skills on electrolyte and non-electrolyte solutions. The control variable is the material of electrolyte and non-electrolyte solution.

The learning tools used in this study were the syllabus, lesson plan (RPP), and student worksheets (LKS) regarding the difference in electrical conductivity between dilute and concentrated solutions usinglearning models *problem solving*. The instruments used in this study were pretest and posttest questions to measure students' science process skills and student activity observation sheets.

The data of pretest scores and posttest scores were used to calculate *n-gain*. According to Hake (1998) theformula *n-gainis* as follows:

n-gain =%Score postes -% score pretest100 -% score pretest

Having obtained *n-gain* every student, then calculate the average *n-gain* every class with the following formula:

average *n-gain* per class =Σ*n-gain* the whole studentsAll students The criteria for classifying *n-gain* according to Hake (1998) are in Table 1.

Table 1. Classification of *n-gain*

Size <g>	Interpretation
<g> 0.7	High
0.3 ≤ <g> <0.7	Medium
< g> <0.3	Low

Two-AveragePre-Score

Similarity TesttestThe two-average similarity test was carried out using parametric statistical tests, namely by using thetest*t*-. The formula used in thetest*t*- is as follows:

$t_{count = X1\text{-}X2s1n1+1n2}$ with s^2 =n1-1s12+ n2-1s22n1+n2-2

Test criteria: accept H_0 if $t_{count} < t_{table}$ rejectH_0 for other t prices with a significant level of 5% .

Two-Mean Difference Test *n-gain*

The two-mean difference test was carried out using parametric statistical tests, namely by using thetest*t*-. The formula used in thetest*t*- is as follows:

$t_{count = X1\text{-}X2s1n1+1n2}$ with s^2 =n1-1s12+ n2-1s22n1+n2-2

Test criteria: accept H_0 if $t_{count} < t_{table}$ rejectH_0 for other t prices with a significant level of 5% .

Percentage of Student

Activities The observed activities of students were asking questions, expressing ideas or opinions, and collaborating. To analyze student activities, it is done by calculating the percentage of each activity for each meeting with the following formula:

% activity i = students who carry out activities is students x 100%

Then interpret the data by interpreting the price of the percentage of student activities as in Table 2.

Table 2. Student activity criteria

Percentage	**Criteria**
80.1% - 100.0%	Very high
60.1% - 80.0%	High
40.1% - 60.0%	Medium
20.1% - 40.0%	Low
0.0% - 20.0%	Very low

(Sunyono, 2012)

- **RESULT AND DISCUSSION**

Based on research that has been conducted on the experimental class and control class at Al-Azhar 3 Senior High School Bandar Lampung, data obtained in the form of pretest and posttest scores of students' science process skills and student activity data . The data was then processed using *Microsoft Office Excel* 2010.

Test the similarity of the two average pretest scores

Before thelearning model was applied *problem solving* to the experimental class, a pretest was conducted to determine the students' initial abilities. The calculation of the average pretest score of science process skills in the experimental and control classes is presented in Figure 1.

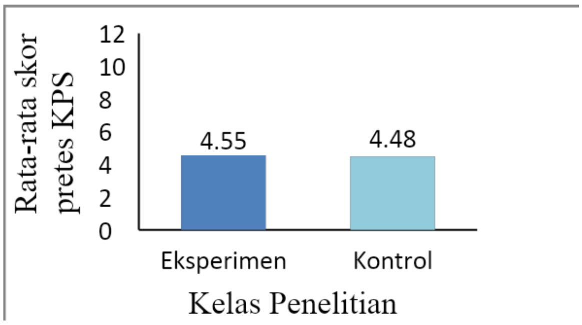

Figure 1. The average KPS pretest scores of students in the experimental and control classes.

Figure 1 shows that the average pretest scores in the experimental class and control class are relatively the same. Furthermore,done *matching is* by testing the similarity of the two averages. Before conducting the similarity test of the two average pretest scores, a prerequisite test was carried out, namely the normality test and the homogeneity test in the two research classes. The normality test for the pretest scores of the two classes was carried out with the Chi-Square test with the acceptance test criteria H_0 if $x^2_{count} \leq x^2_{table}$. The results of the normality test on the students' science process skills pretest scores are presented in Table 2.

Based on Table 2 shows that $x^2_{count} < x^2_{tables}$ in the experimental class and in the control class. So it can be concluded that the two research classes are normally distributed.

Table 2. The results of the normality test of students' science process skills pretest scores.

Class	Normality Test			Decision Test
	X^2_{count}	X^2_{Table}	Test Criteria	
Experimental	3,04	7,81	If $x^2_{count} < x^2_{tables,}$ then accept H_0	Accept H_0
Control	1.71	7.81		Accept H_0

The next prerequisite test is the homogeneity test of students' science process skills pretest scores with acceptance test criteria H_0 if $F_{count} < F_{table}$. The results of the homogeneity test obtained F_{count} 1.04 and F_{table} 1.84. These results indicate that$F_{count} < F_{table}$, so the test decision is accept H_0, meaning that the two research classes
have homogeneous variances.

Based on the normality test of the pretest scores, the results showed that the two research classes were normally distributed and based on the homogeneity test of the pretest scores, the results showed that the two research classes had homogeneous variants, so the two-average similarity test was carried out using the-test*t*.

The results of the test usingtest*t*- obtained t_{count} of 0.18 and t_{table} of 1.67. These results indicate that $t_{count} < t_{table}$, so the test decision is accept H_0, which means that the average pretest score of students' science process skills in the experimental class is the same as the average pretest score of students' science process skills in the control class. So it can be concluded that the two research classes have the same initial ability.

The difference test of two average post-test scores

The calculation of the average post-test scores of science process skills in the experimental and control classes is presented in Figure 2.

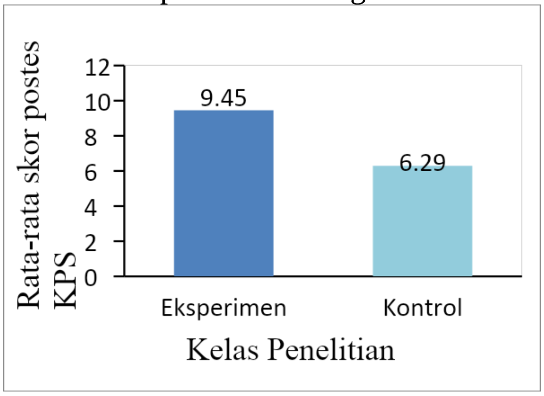

Figure 2. The average post-test scores of students in the experimental and control classes.

Based on Figure 2, the average posttest score of science process skills in theclass experimentalis higher than the control class, where the experimental class is 9.45 while the control class is 6.29 with a maximum score of 12. Then to determine whether the average score of the second posttest the research class differs significantly, then the two-mean difference test is carried out. Before testing the difference between the two averages, the prerequisite tests were first carried out, namely the normality test and homogeneity test.

The normality test for the posttest scores of the two classes was carried out with the Chi-Square test with the acceptance test criteria H_0 if $x^2_{count} \leq x^2_{table}$. The results of the normality test on the students' science process skills posttest scores are presented in Table 3.

Table 3. The results of the normality test of science process skills posttest data.

Class	Normality Test			Decision Test
	x^2_{count}	x^2_{Table}	Test Criteria	
Experimental	5,71	7,81	If $x^2_{count} < x^2_{table,}$ then accept H_0	Accept H_0
Control	5,60	7,81		Accept H_0

Based on the results in Table 3, it can be seen that $x^2_{count} < x^2_{tables}$ in the experimental class and control class, then accept H_0 which means that the post-test scores of students' science process skills in both research classes are normally distributed. The next prerequisite test is the homogeneity test of students' science process skills posttest scores. The results of the homogeneity test obtained F_{count} 1.25 and F_{table} 1.84. Under the means test criteria accept H_0 which means that both studies have variances homogeneous class.

Based on the posttest score normality test, the results showed that the two research classes were normally distributed and had homogeneous variants, so the two-average difference test was carried out using the-test*t*. The test results show that the value of $t_{count\ is}$ 8.78 and $t_{table\ is}$ 1.67. These results indicate that $t_{count} > t_{table}$, so the test decision is reject H_0, which means that the average post-test score of students' science process skills applied by thelearning model *problem solving* is higher than the average post-test score of students' science process skills with conventional learning. So it can be concluded that there is a significant difference in the average post-test scores of students' science process skills between the experimental and control classes.

Calculation of n-gain

The calculation of the average *n-gain for* the experimental class and the control class is presented in Figure 3.

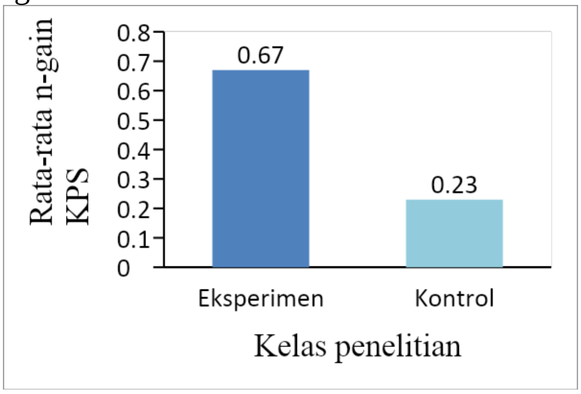

Figure 3. The average *n-gain* KPS of the experimental class and control class students.

Based on Figure 3, it can be seen that the average *n-gain of* the experimental class is higher than the average *n-gain of* the control class. Based on the classification of *n-gain* according to Hake (1999), the average *n-gain of* the experimental class is 0.67, including the medium category, so it can be concluded that the problem solving learning model on electrolyte and non-electrolyte solutions is effective for improving science process skills.

Student activities

During the learning process starting from introduction to closing, student activities in the experimental class that appliedlearning models were *problem solving* observed by 2 observers and the assessment used student activity sheets.

a. Asking The

percentage of students' asking activities at each meeting is shown in Figure 4.

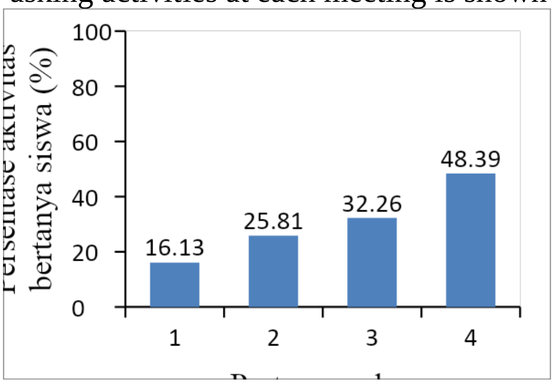

Figure 4. The percentage of students' asking activities at each meeting.

Based on Figure 4, it can be seen that the activity of asking students from the first meeting to the fourth meeting has increased. At the 1st meeting until the 3rd meeting the criteria were low, the 4th meeting had moderate criteria.

b. Expressing ideas/opinions The

percentage of activities expressing students' ideas/opinions at each meeting is presented in Figure 5.

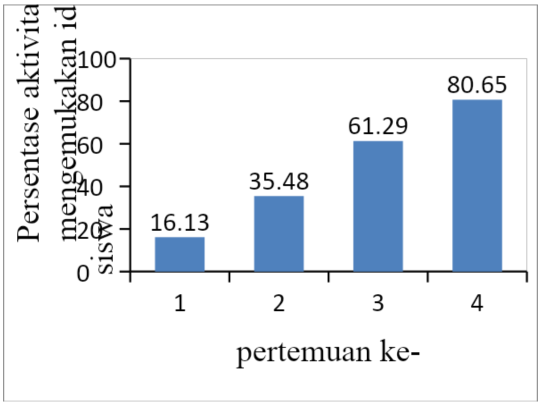

Figure 5. The percentage of activities expressing students' ideas at each meeting.

Based on Figure 5, it can be seen that the percentage of activities in expressing students' ideas or opinions from the first meeting to the fourth meeting has increased. At the first meeting has very low criteria, the second meeting has low criteria, the 3rd meeting has high criteria, and the 4th meeting has very high criteria.

c. cooperate The

percentage of students' cooperative activities at each meeting is presented in Figure 6.

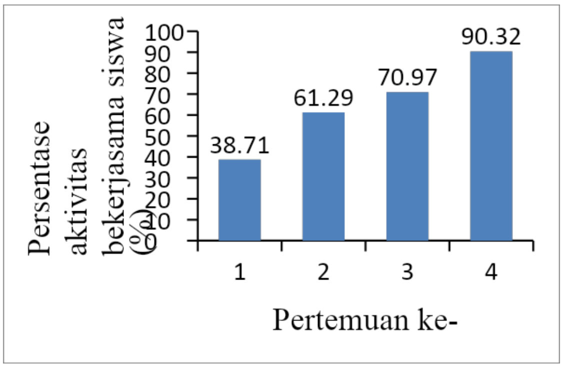

Figure 6. The percentage of students' cooperative activities at each meeting.

Based on Figure 6, it can be seen that students' collaborative activities from the first meeting to the fourth meeting have increased. At the 1st meeting has low criteria, the 2nd meeting has high criteria, the 3rd meeting has high criteria and the 4th meeting has very high criteria.

Stage 1. Formulating the Problem

In this lesson, it can be seen that students are quite active in asking questions and the questions asked by students are in accordance with what the teacher expects. This is supported by the percentage of student activity asking 48.39% with moderate criteria. At this stage students have also shown good cooperative activities in group discussions which are supported by the percentage of student collaboration activities of 90.32% which is categorized as very high. At the stage of formulating the problem, the students' science process skills are trained, namely the skill of asking questions which is supported by students' asking activities.

Stage 2. Seeking Information

Second stage on thelearning model *problem solving* that is looking for information. At this stage, students are asked to find information that can be used to solve problems that have been found. At this stage, students are required to play an active role in seeking as much information as possible from various relevant sources. The information obtained at this stage is used to guide the process of formulating a hypothesis. The following is one of the groups who have been looking for information and then write it down on the LKS.

Stage 3. Formulating the Hypothesis

At the stage of formulating this hypothesis, the observed student activities are expressing ideas/opinions. In the activity worksheet, the activity of expressing ideas/opinions of students is quite good, which is shown when students conduct group discussions, it can be seen that many students submit ideas/opinions, answer questions and refute the opinions of other friends. This is supported by the percentage of activities expressing ideas/opinions of students by 80.65% which has very high criteria. At the stage of formulating this hypothesis, hypothetical skills are trained so that they can improve students' science process skills.

Stage 4. Collecting Data

At the stage of collecting data, students are able to design experimental procedures quite well. At the time of designing the experiment, students looked disciplined which was shown in an orderly manner following the lesson and submitting assignments on time. Students are also seen expressing ideas or opinions that are shown by arguing with each other about the experiment being designed. This is supported by the percentage of student discipline activities of 87.10 with very high criteria and the percentage of activities expressing student opinions of 80.65% which has very high criteria.

Furthermore, students have written observations quite well, but in a solution of CH_3COOH dilute and concentrated that are dimly lit and a little gas bubbles. Supposedly written observations on the bulb and lots of gas bubbles in detail, namely CH_3COOH concentrated dimly lit but lighter than CH_3COOH CHdilute and$_3$COOHconcentrated cause little gas bubbles but many of CH_3COOH watered. This also applies to dilute and concentrated NaCl solutions. And concentrated aqueous NaCl brightly lit and caused many gas bubbles, but lighter than the concentrated NaCl aqueous NaCl and concentrated NaCl caused many gas bubbles but more than CH_3COOH watered.

Activities that arise during the experiment are good cooperation as indicated by the percentage of cooperative activities of 90.32% which has very high criteria. This stage of collecting data can practice skills in using tools/materials and carrying out experiments so as to improve students' science process skills.

Stage 5. Analyzing Data

At this stage students are able to answer questions well and in accordance with the observations obtained. It can be seen that students are able to describe the submicroscopic ions that decompose in NaCl solution well and can relate them to the knowledge that has been obtained previously. At the stage of analyzing this data, in answering these questions students have shown good cooperative activities in group discussions which are supported by the percentage of student collaboration activities of 90.32% which is categorized as very high and the percentage of activities expressing student ideas/opinions is 80, 65% are very high criteria. Student activities at this stage can practice the skills of applying concepts so that they can improve students' science process skills.

Stage 6. Concluding

At the concluding stage, students conduct group discussions that look disciplined, orderly and conducive in participating in learning, students also share ideas/opinions and work well together. This is supported by the percentage of student discipline activities of 87.10% which has very high criteria, the percentage of expressing ideas/opinions is 80.65% which has very high criteria and the percentage of cooperation is 90.32% which has very high criteria.

The stages in thelearning model *problem solving* provide good achievements in the experimental class because they can train students' scientific process skills. At the stage of formulating problems, formulating hypotheses, collecting data, analyzing data can train and improve students' science process skills.

Based on the results and discussion, this research is in accordance with previous research regardinglearning models *problem solving*. Aka, Guven & Aydogdu (2010) proved that the experimental group students who used thelearning model *problem solving* had a higher average score than the control group students. Then the research of Hartini, Kusasi & Irani (2017) proves that thelearning model is *problem solving* effective in improving science process skills on salt hydrolysis material. This is in accordance with this study that students' science process skills can be trained withlearning models *problem solving.*

• CONCLUSION

Based on the data analysis of the results of the research and discussion, it can be concluded that: (1) The average *n-gain* problem solving ability of the experimental class students is in the high category and the control class is in the medium category. (2) There is a significant difference in the *n-gain* of problem solving skills between the experimental class and the control class. (3) Learning by usinglearning model is *guided discovery* effective to improve students' problem solving ability.

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