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STEM-Project Based Learning with Learning Guides on Electrolyte and Non-Electrolyte Solutions to Improve Higher Order Thinking Skills of High School Students

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Abstract: The purpose of this study was to examine the effect of STEM-Project Based Learning with learning guides on the Concept of Electrolyte and Non-Electrolyte Solutions on the ability to think of high order students of class X SMA Negeri 3 Palangka Raya. The study used a quasi-experimental method with a nonequivalent control group design. The research sample was 35 students of Class X MIPA 1 as a control class and 36 students of Class X MIPA 5 as an experimental class. STEM-Project Based Learning with learning guides is done using the help of study guides. Data collection of higher order thinking skills is carried out using tests (pretest and posttest) specifically designed to measure higher order thinking skills. The data obtained were statistically analyzed using the t test to compare the increased thinking ability of the kontrol class and the experimental class. The statistical test results obtained that t_{count} is greater than t_{table}, that is t_{count} = 21.74 greater than t_{table} = 2.032, which shows that the average increase in high order thinking skills of experimental class students is better than the average increase in the ability of thinking of control class students. Thus, it can be concluded that STEM-Project Based Learning with learning guides on the Concept of Electrolyte and Non-Electrolyte Solutions can improve higher order thinking skills.

Keywords: electrolyte and non-electrolyte solutions, STEM-Project Based Learning, high order thinking.

Abstrak: *Tujuan penelitian adalah menelaah pengaruh pembelajaran STEM-Project Based Learning with learning guides pada Konsep Larutan Elektrolit dan Non Elektrolit terhadap kemampuan berpikir tingkat tinggi siswa kelas X SMA Negeri 3 Palangka Raya. Penelitian menggunakan model kuasi eksperimen dengan desain nonequivalent kontrol group. Sampel penelitian adalah 35 siswa Kelas X MIPA 1 sebagai kelas kontrol dan 36 siswa kelas X MIPA 5 sebagai kelas eskperimen. Pembelajaran STEM -Project Based Learning dilakukan dengan menggunakan bantuan panduan belajar. Pengumpulan data kemampuan berpikir tingkat tinggi dilakukan menggunakan tes (pretes dan postes) yang dirancang khusus untuk mengukur kemampuan berpikir tingkat tinggi. Data yang diperoleh dianalisis secara statistik menggunakan uji t untuk membandingkan peningkatan kemampuan berpikir kelas kontrol dan kelas ekperimen. Hasil uji statistik diperoleh thitung lebih besar dari* t_{tabel} *yaitu* t_{hitung} *= 21,74 lebih besar dari* t_{tabel} *= 2,032 yang menunjukkan bahwa rata-rata peningkatan kemampuan berpikir tingkat tinggi siswa kelas eksperimen lebih baik dari rata-rata peningkatan kemampun berpikir siswa kelas kontrol. Dengan demikian dapat disimpulkan bahwa pembelajaran STEM - Project Based Learning pada Konsep Larutan Elektrolit dan Non Elektrolit dapat meningkatkan kemampuan berpikir tingkat tinggi.*

Kata kunci: *Larutan elektrolit dan non -elektrolit, STEM -Project Based Learning, berpikir tingkat tinggi.*

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▪ INTRODUCTION

Mastery of contextual knowledge according to the region and each environment is the focus of the K13 curriculum which focuses on three assessments, namely, attitudes (honest, polite, discipline), skills (through practical assignments/school projects), and scientific knowledge (Mawaddah & Wancik, 2017). The learning applied to the 2013 curriculum fosters cognitive, affective and psychomotor skills (Santosa, Razak & Arsih, 2021). The curriculum mandate states that the competency standards for graduate students at high school level include having the ability to think and act creatively, productively, critically, independently, collaboratively, and communicatively (Ministry of Education and Culture, 2016). The learning strategy designed by the teacher is one of the keys to successful learning by being oriented to the curriculum, teaching materials, and student characteristics (Farwati & Suhery, 2018). It can be seen that the aspect of creativity is an important thing that needs to be instilled in every learning (Ismayani, 2016).

21st century learning ideally directs students to be responsive and have abilities in all fields in accordance with the development of science and technology (Ningsih, 2018). The 21st century has caused a shift in both characteristics and learning models in the world of education in Indonesia, which aims to produce Indonesian people who are productive, creative, innovative, and affective through strengthening attitudes (know why), skills (know how), and knowledge (know what). integrated (Septiani, 2018). The implementation of the learning process using a scientific approach should be able to develop the thinking skills needed in the 21st century including critical thinking, problem solving, creativity, and metacognitive. One of the important things that need to be observed in the learning process in the classroom is honing students' abilities in the form of high order thinking skills (HOTS), with the aim of increasing students' ability to think reasoning to answer questions or solve a more complex case/problem. complicated (Fitri, Dasna & Suharjo, 2018)

Learning objectives can be achieved both by students and teachers by finding out factors, innovations, either how to improve, modify, add or replace models that lead students to effective and meaningful learning in every learning process. Through providing direct experience by carrying out a series of science processes where the learning process is more activating and motivating students in developing their reasoning power in planning and solving problems encountered such as project-based learning, it is expected to improve students' science process skills better than before (Sumarni & Supanti, 2011). 2019)

Learning using conventional models is mostly dominated by the teacher, students only listen and take notes from the teacher's delivery which can result in a lack of student activity in participating in the learning process so that it can result in passive students (Pratama, 2019). Monotonous learning is one of the causes of students experiencing boredom in the learning process so that students' creative thinking power does not develop and even tends to have a lower impact on student learning outcomes (Amatullah & Wahyudi, 2019). Law number 14 of 2005 article 10 paragraph 1 states that a teacher must have several competencies, one of which is professional competence, namely teachers are required to have a high spirit of professionalism including the ability to develop teaching materials (Nessa & Hiltrimartin, 2017). Learning that is in accordance with the characteristics of science and students' needs still cannot be implemented because the development of teaching materials is still not optimal and the limitations of science teaching materials in supporting integrated learning by teachers (Sugianto & Wulandari, 2018).

Scientific work experience is given to students who can improve learning outcomes and higher-order thinking skills as a form of improving the quality of learning that emphasizes the learning process (Setiawan, 2011). Process abilities, including applying, analyzing, evaluating and creating with the basics of a good remembering and understanding process are indicators of higher order thinking skills (Yuliati, 2013). Higher order thinking skills can be achieved through productive learning activities that are able to make students collaborate and explain the concepts that have been given (Widodo & Kadarwati, 2013). Manipulating ideas in a certain way that gives students new understanding and implications can be realized through the students' higher-order thinking skills (Robiah, 2018). Higher order thinking skills in chemistry learning are very important where students are asked to be able to analyze a problem so that conclusions can be drawn (Kurniati & Effendi, 2017). critical thinking is a process that leads to drawing conclusions about what we should believe and what actions we will take.

STEM-based science learning (science, technology, engineering, and mathematics) in the implementation of problem-based learning units (problem based learning), exposes students to be able to think critically, creatively, and innovatively in order to solve real problems through group (team) activities in a collaborative form (Satriani, 2017). The learning approach using STEM integrates several disciplines where learning materials are the result of knowledge and technology integrated with mathematical and engineering components (Suhery, 2017). Learning using STEM helps students gain complete knowledge, be more skilled and prepare skills to face 21st century developments (Lestari & Darsono, 2018).

The shift in the mode of the learning process from being teacher centered (teacher centered) as a conventional mode that relies on knowledge transfer towards student centered learning (student centered) as a mode of learning is a mode that relies on student activity, hands-on, and collaboration. The STEM-PjBL-based chemistry learning design in the classroom is useful in providing opportunities for students to apply academic knowledge in the real world (Satriani, 2017). The implementation of STEM-PjBL in learning is invited to explore through a project activity, so that students are actively involved in the process so that learning is more meaningful and easy to understand a concept because it fosters critical, creative, analytical thinking, and improves which are high-level thinking skills (Sumarni & Supanti, 2019).

▪ METHOD

The approach used in this study is a quantitative approach. While the model and research design used was a quasi-experimental (Quasi-Experimental) and one-group pretest and posttest design. The dependent variable in this study is students' high-level thinking and the independent variable in this study is the STEM-Project Based Learning with learning guides. In addition, the population in this study were all students of class X MIPA SMAN 3 Palangka Raya with a sample of 35 students of class X MIPA 1 as the control class and 36 students of class X MIPA 5 as the experimental class. The sampling technique in this study used a purposive sampling technique, namely by selecting two classes. With details of the class being the sample is one class as the experimental class and the other class as the control class. The experimental class is the class that gets treatment using the STEM-Project Based Learning with learning guides and is supported by the "Student Learning Guide" while the control class uses the lecture learning model and is supported by conventional-based student books.

Quantitative data collection techniques in this study were obtained from students' higher order thinking ability test instruments in the form of pretest data, posttest data and n-gain data. Qualitative data obtained from non-test instruments in the form of observations and results of student response questionnaires. The test instruments consist of: (1) pretest questions which aim to determine students' initial higher order thinking abilities, and (2) posttest questions aim to determine students' final high order thinking abilities after being given learning by learning STEM-Project Based Learning with learning guides. The non-test instruments consist of: (1) teacher and student activity observation sheets that aim to describe the implementation of chemistry learning with the STEM-Project Based Learning with learning guides and (2) student response questionnaire sheets that aim to determine student responses to learning mathematics using STEM-Project Based Learning with learning guides. Before being used in research, the test instrument must be tested first. The test results of the instrument were then analyzed to determine the validity, reliability, difficulty index, and discriminating power. After knowing the results, then valid and reliable questions are used in the study.

The quantitative data in this study were analyzed for practicality and effectiveness, namely the effectiveness for learning guides from the aspect of increasing understanding of concepts determined using the N-gain score (pretest-posttest) as used by Hake (1998). LKS is declared effective if the N-gain score 0.5, and the analysis of the magnitude of the contribution of the ability to construct concepts to the improvement of concept understanding is determined using Pearson Product Moment followed by calculating the coefficient of determination. Meanwhile, qualitative data analysis for observation sheets was analyzed descriptively and student response questionnaire data were analyzed to determine student responses by transforming initial data in the form of ordinal data to interval data.

▪ RESULT AND DISSCUSSION

A. Students' understanding of the concept of electrolyte and non-electrolyte solutions

Based on the calculation results of the N-gain score test, the percentage of N-gain is at least 64.71% and a maximum of 89.58% so that the average percentage of N-gain for the experimental class (STEM-Project Based Learning with learning guides) is equal to 76.09%, the effectiveness interpretation states that learning with this model is included in the effective category and the N-gain shows an average Ngain of 0.76 which indicates the high category. While the percentage of N-gain score for the control class (conventional) is a N-gain value of 17.39% and a maximum of 47.62% so that the average N-gain of 25.73% is included in the ineffective category and the Ngain value shows an average N-gain of 0, 26 which shows the low category (Malzer in Syahfitri, 2008:33).

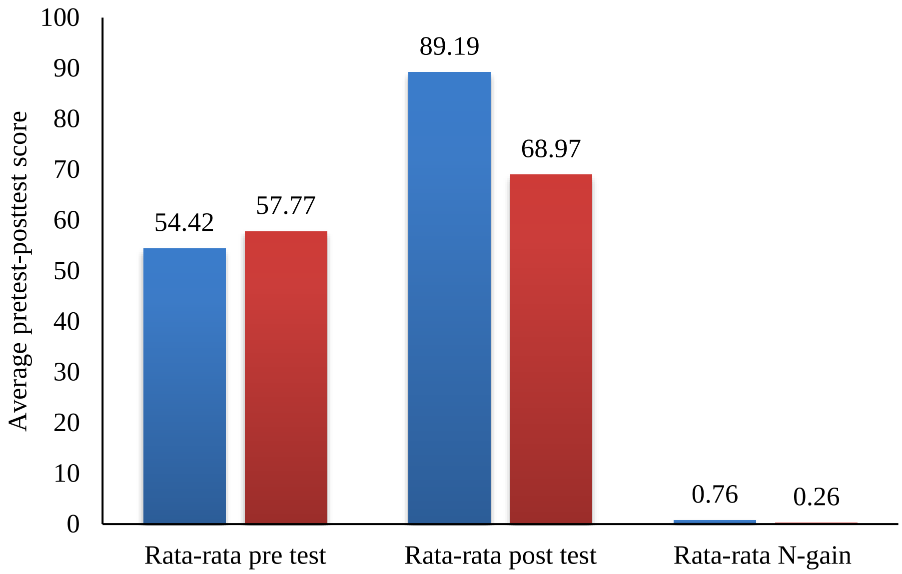
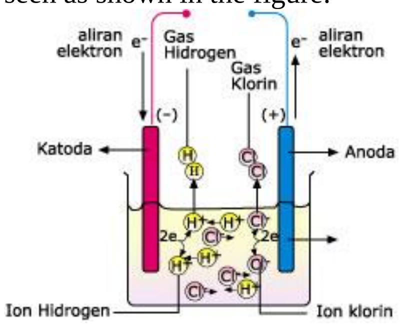


Figure 1. N-gain score of experimental (blue) and control group (red)

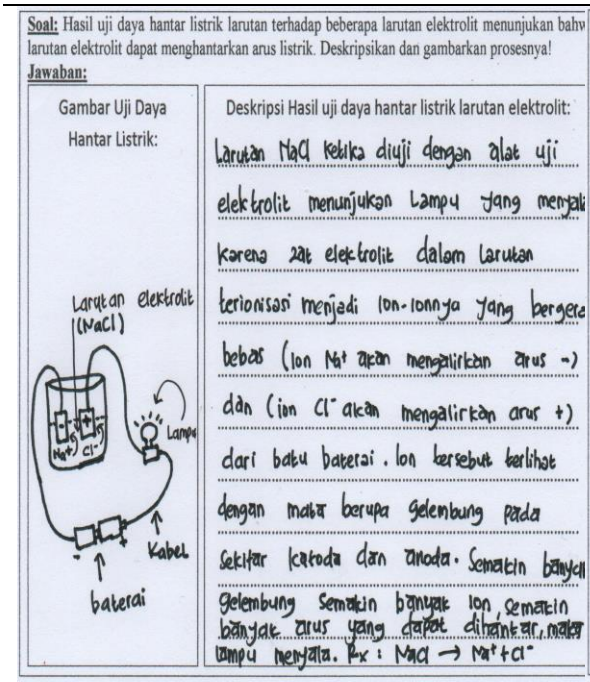
Examples of student answers for GPA 3 with the aim of learning to analyze (C4) the causes of electrolytes to conduct electric current, as follows:

Problem:
The results of the electrical conductivity test of the solution against several electrolyte solutions show that the electrolyte solution can conduct electric current. Describe and describe the process!

Answer Key: An example of an electrolyte solution in an experiment that has been designed and applied by students is HCl. HCl solution in water breaks down into cations (H^+) and anions (Cl^-). The occurrence of electrical conductivity in the HCl solution is caused by H^+ capturing electrons at the cathode by liberating hydrogen gas (H_2).ions$^-$release electrons at the anode to produce chlorine gas (Cl_2). It can be seen as shown in the figure:



Electrical conductivity is related to the ions in solution. The flow of electric current is in the form of particle movement in the form of electrons and ions particles. When passed into an electrolyte solution, an electric current will be carried by the ions in the solution so that the lamp can light up. The more ions in the solution, the stronger the conductivity of the solution. That is why the light of a strong electrolyte solution is brighter than a weak electrolyte solution.



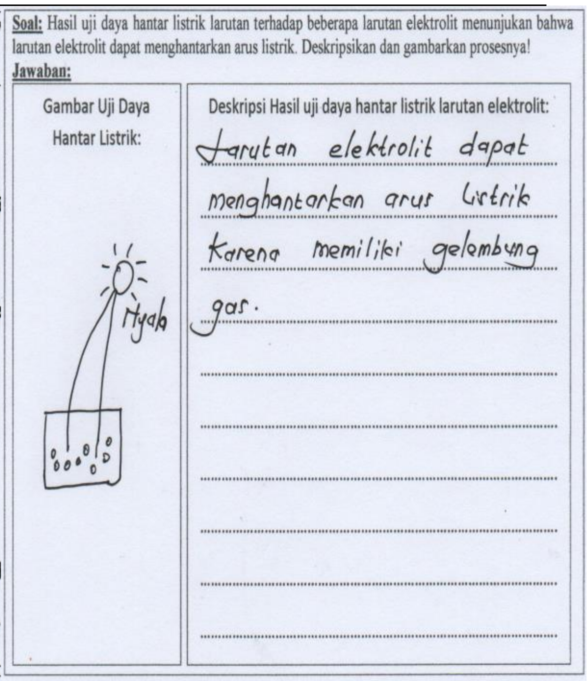


Figure 2. Examples of student answers in the experimental class using the STEM-Project Based Learning with learning guides model with the help of study guides

Figure 3. Examples of student answers in the control class with conventional learning

Students' answers in the experimental class using the STEM-Project Based Learning with learning guides model with the help of a study guide showed students better understand the concept of how the electrolyte solution can conduct electric current compared to the control class with conventional learning. Students in the experimental class are able to explain and understand that electrolytes in their solvents break down into cations and anions. Electrical conductivity is related to the ions in solution. The flow of electric current is in the form of particle movement in the form of electrons and ions particles. When passed into an electrolyte solution, an electric current will be carried by the ions in the solution so that the lamp can light up. The more ions in the solution, the stronger the conductivity of the solution. That is why the light of a strong electrolyte solution is brighter than a weak electrolyte solution.

Chemistry learning in the experimental class using the STEM-Project Based Learning with learning guides with the help of a study guide affects students' conceptual understanding of the material Electrolyte Solution and Non-Electrolyte Solution successfully understands well on all learning indicators, including: 1. Comparing (C4) the electrolyte properties of several solutions in the environment and solutions in the laboratory based on experimental results; 2. Grouping (C2) solutions into strong electrolytes, weak electrolytes, and nonelectrolytes based on their electrical conductivity; 3. Analyzing (C4) the types of chemical bonds and the electrolyte properties of a substance and concludes that the electrolyte solution can be in the form of ionic compounds or polar covalent compounds; 4. Check connection (C4) of electrocuted animals with flooding; 5. Summarizing (C4) the function of electrolyte solutions in the human body and how to overcome electrolyte deficiencies in the body. The achievement of the above learning indicators is influenced by STEM-Project Based Learning with learning guides with the help of study guides guiding students to acquire: 1) critical thinking skills in asking questions and finding answers on their own with the group; 2) the skill of expressing opinions or questions in group discussions or between groups in class which makes students have more knowledge.

Whereas in the control class that uses conventional models in achieving learning indicators, not all of them can be achieved well, namely in indicators 3) Analyzing the types of chemical bonds and electrolyte properties of a substance and concluding that electrolyte solutions can be ionic compounds or polar covalent compounds and why. students only listen and take notes from the teacher's delivery which can result in a lack of student activity so that knowledge is limited only to what is conveyed by the teacher and students do not understand knowledge in depth.

B. The relationship between critical thinking skills and concept understanding

The results of the correlation analysis of critical thinking skills on students' conceptual understanding obtained a regression coefficient, r = 0.96. This means that there is a very strong correlation between thinking skills and concept understanding. The contribution of critical thinking skills to understanding the concept was analyzed using a coefficient of determination with a result of 93.32% and the remaining 6.68% was determined by other variables. This shows that students' thinking skills have an effect on increasing students' mastery of concepts in chemistry learning using the STEM-Project Based Learning with learning guides with the help of study guides, which strongly influences students' conceptual understanding of the material Electrolyte Solutions and Non-Electrolyte Solutions as shown by the value of t count = 21 .74 which is greater than ttable = 2.032. The results of this study are in line with Setiawan's research. (2011) which states that the learning model and initial ability have an effect on improving student learning outcomes and critical thinking skills.

C. Questionnaire analysis of student responses to STEM-Project Based Learning with learning guides with learning guides

Students' questionnaire analysis was conducted to see students' opinions on the learning guides used by teachers in chemistry learning activities using the STEM-Project Based Learning with learning guides, questionnaires were given to 71 students consisting of from 2 classes, it was obtained that: (1) 68 students with a percentage of 95.77% of the total number of students stated that the use of study guides as a learning resource in learning activities of electrolyte and non-electrolyte solutions using the STEM-Project Based Learning with learning guides was very effective in improving students' conceptual understanding; (2) 60 students with a percentage of 84.51% of the total number of students stated that the study guide used made students have higher-order thinking skills towards electrolyte and non-electrolyte solutions; (3) 62 students with a percentage of 87.32% of the total number of students stated that the study guide used made students understand the material concept of the existing questions; (4) 58 students with a percentage of 81.69% of the total number of students stated that the study guide used was able to make students apply chemistry material in everyday life. So that the average percentage shows a high response, which is 87.32%, which means that chemistry learning activities using the STEM-Project Based Learning with learning guides with the help of study guides are stated to be very good and effective in developing students' high-level thinking skills in learning electrolyte and non-electrolyte materials. electrolyte.

▪ CONCLUSION

Based on the results of the analysis of research findings and discussions that have been described, it can be concluded that: (1) The results of statistical tests obtained that tcount is greater than ttable , namely tcount = 21.74 greater than ttable = 2.032 which indicates that the average the improvement of high-order thinking skills of class students who use the STEM-Project Based Learning with learning guides study guides is better than the average improvement of students' thinking skills in the control class; (2) The results of the correlation analysis and the coefficient of determination show that there is a correlation and contribution of thinking skills to students' understanding of concepts in chemistry learning using the STEM-Project Based Learning with learning guides assisted by students' concept study guides on the material of electrolyte solutions and non-electrolyte solutions; (3) Most (87.32%) students agreed with chemistry learning by using the STEM-Project Based Learning with learning guides with learning guides on electrolyte and non-electrolyte solution materials to improve students' higher order thinking skills

Implementation of the use of study guides as a learning resource in electrolyte and non-electrolyte solution learning activities using the STEM-Project Based Learning model is able to assist teachers in realizing innovative learning, improving students' critical thinking skills through increasing student activities in students building and understanding concepts studied. This learning requires planning that takes a long time so that time management is needed in each activity starting from planning, implementation to evaluation.

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