

SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) APPROACHES TO IMPROVING STUDENTS' LEARNING OUTCOMES IN THE SUBJECT OF REDOX REACTIONS

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Abstract

The rapid development of science and technology affects the world of education. The challenge for 21st century educators is that teachers are required to be able to carry out innovative learning by utilizing technology to prepare students for the real world and ready to face global challenges. One approach that meets these demands is the Science, Technology, Engineering, and Mathematics (STEM) approach by applying four disciplines, namely science, technology, engineering and mathematics, as well as combining knowledge and skills. The purpose of this review is to find out the role of the STEM approach in improving student learning outcomes in the Redox Reaction chemistry subject for class XII. The method used is by collecting and reviewing data through literature studies from several relevant articles using the VOSViewer application and using the n-Gain enhancement test. The results of a review of 20 articles and 3 articles analyzed obtained data that the STEM learning approach was effective in improving student learning outcomes in Redox Reaction chemistry learning with an average increase in learning outcomes in the medium category. Through this category, learning with the Science, Technology, Engineering, and Mathematics (STEM) approach is able to improve student learning outcomes.

Keywords: Learning Outcomes, STEM Approach, Redox Reaction

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INTRODUCTION

In the 21st century, the mastery of Science and Technology (IPTEK) is very important to face the challenges of the future. This challenge occurs due to the development of the times which makes the rapid development of science and technology and results in the emergence of competition. Therefore, students as human resources are expected to be able to compete globally which can be done through education (Irmita, 2018). The learning skills that are required today include critical thinking, communicating, creativity, and collaboration or also known as 4C skills (Critical Thinking, Communiacion, Collaboration, Creativity). Learning in the 21st century directs students to be able to adapt to innovation and technological progress. However, looking at the development of education in Indonesia, it can be seen that the application of 21st century learning is still insufficient. This is in line with the results of the PISA (Programme for International Students Assessment) study conducted by the OECD (Organization of Economic Co-operation and Development) found that the performance of 15-year-old students in mathematics and science is dominated by the top countries, including China, Singapore, Taiwan, South Korea, Finland, and Switzerland. Conversely, students in developing countries are on average below developed countries (Permanasari, 2016). This shows that there is a direct relationship between skills in the field of education (especially mathematics and science) and the economic level of a country. Inadequate education, especially in mathematics and science, results in a lack of quality workforce in the global industry (Cooney & Bottoms, 2003)

In general, the learning process in the classroom is not effective if the ability and response of the students has not been optimally achieved. The success of the learning process is also related to the teacher's ability to develop learning models that refer to increasing student involvement in the learning process. However, it turns out that what happened in the field is that there are still many learning outcomes of students who get grades below the minimum completion criteria (KKM) (Suriti, 2021). The learning outcomes of the students are still not optimal, because during the learning process the use of models, methods or approaches are less effective. Where learning in the classroom is only studying products and knowing facts without any process of self-discovery, and students are not yet able to use their knowledge in solving problems faced in everyday life.

In the process of learning chemistry at school, the understanding of learning becomes an important part, where the materials taught to the students are not only memorized, but more than that so that the understanding of the concept of the subject matter presented can be better understood. However, the

existing facts show that the learning outcomes of students in the field of chemical studies are still low. This is because their ability to understand the learning of chemistry is only limited to the theoretical and has not reached the applicative understanding. One of the chemical materials that is still a problem for students is the redox reaction material. The material requires a high level of understanding and must be able to be applied by each student. This condition can be seen from the results of the daily assessment of XII grade students who only reached a score of 70 from the school's KKM of 75. This is because students tend to be passive, less creative and not able to solve problems well (Suriti, 2021)

Therefore, it is necessary to apply a learning process that can activate the participation of students and integrate knowledge that is a need for 21st century education. One of the learning that can be applied is learning with the STEM (Science, Technology, Engineering, and Mathematics) approach. STEM allows students to learn abstract concepts from all aspects by applying the four disciplines of science, technology, engineering expertise and mathematics. These four aspects are needed at the same time in solving problems, so it can be said that STEM can create an active learning system. In learning chemistry, STEM can help students to use technology and assemble a chemical concept that is proven mathematically (Idrus & Suma, 2022). Tren Education with a STEM approach is also in line with current national education demands. Today's teachers must be "technologically literate" and be able to improve and update their knowledge in their field of expertise so that they can motivate students to continue to innovate (Anugrah et al., 2019)

STEM education is centered on learning towards problem solving (problem solving) and problem posing (problem formulation), so that the STEM approach can be combined with PjBL (Project Based Learning) or PBL (Problem Based Learning) learning models (Mawaddah et al., 2017). An applicable learning approach in the form of STEM (Science, Technology, Engineering, and Mathematics) combines knowledge and skills so that students can easily understand learning well and obtain the expected learning outcomes.

RESEARCH METHODS

This article is the result of reviewing several articles, namely around 20 articles using the VOSViewer application. The first step is to do a literature study by collecting and selecting several articles that are relevant to the existing problems. The next step is to make connections for each article that has been collected using the VOSviewer application. The results of the mapping using the vos viewer application are as shown below.

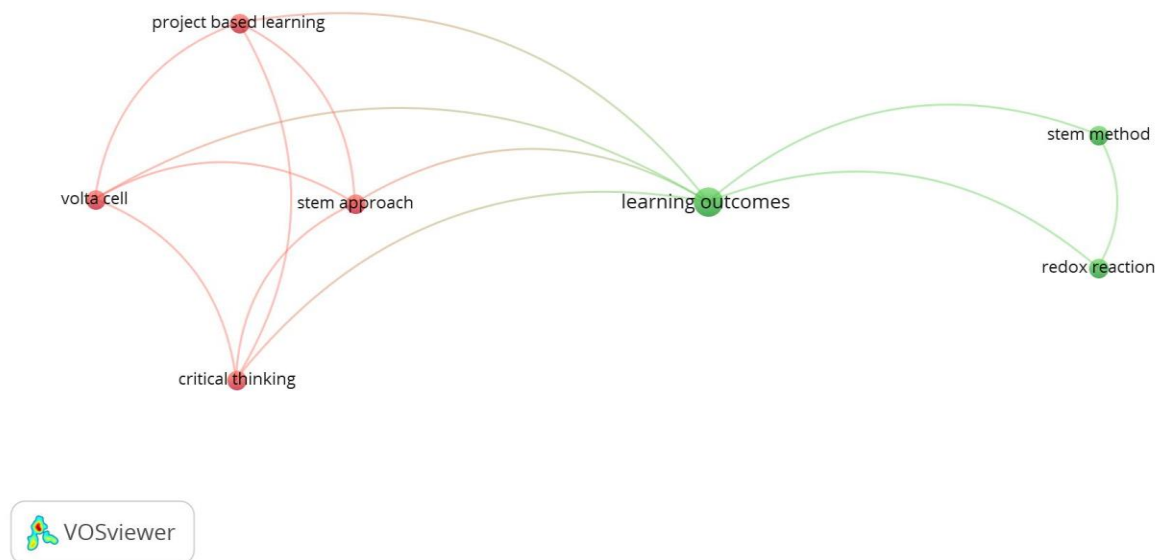


Figure 1. Mapping results with VOSViewer

From the results of the mapping using the VOSViewer application, it can be seen that the keywords are in the form of variables to be analyzed, namely learning outcomes that are directly connected to the STEM approach (STEM approach) and redox reactions (redox reactions) as well as several other clusters. Furthermore, it can determine the relationship between these variables so that a review analysis can be carried out on the STEM approach in improving chemistry learning outcomes on the subject of redox reactions. Review analysis was carried out by taking 3 samples of relevant articles to reprocess them into new data. Analysis of increasing learning outcomes is analyzed using the n-Gain formula. The n-Gain formula according to Hake, 1999 is as follows:

$$n - Gain = \frac{Score\ posttest - Score\ pretest}{Score\ maksimal - Score\ pretest}$$

(Hake, 1999)

The n-gain criteria can be seen in Table 1 below.

Table 1. Criteria for the n-Gain level

| n-Gain | Criteria |
|-----------------|--------------|
| $g \geq 0.7$ | High |
| $0.7 > g > 0.3$ | Intermediate |
| $g \leq 0.3$ | Low |
| $g \leq 0$ | Fail |

(Wahab et al., 2021)

RESEARCH RESULT AND DISCUSSION

The results of reviewing several articles in improving student learning outcomes in learning redox material chemistry using the STEM approach. Of the 20 articles that have been collected in the analysis 3 articles are relevant. Indicators of success in improving student learning outcomes can be seen from the results of observing the activities of students and teachers in learning (Sunardi, 2021). As for the measurement of the percentage of learning outcomes is measured based on n-Gain pretest and posttest results. The results obtained from the three articles are as follows:

Table 2. Improved Learning Outcomes Through Pretest and Posttest Scores

| No | School name | Improved Learning Outcomes | |
|----|---------------------|----------------------------|----------------|
| | | Pretest Value | Posttest Value |
| 1 | SMAN 1 CIGUGUR | 60 | 92 |
| 2 | SMA KRISTEN YABT | 42.8 | 73.3 |
| 3 | SMA NEGERI SALATIGA | 52 | 80.69 |
| | Average | 51.6 | 82 |

The results of the n-Gain acquisition of the three articles analyzed can be seen in the following table:

Table 3. Results of N-Gain Analysis of Increasing Learning Outcomes in Chemistry in Redox Reaction Material

| No | Article | n-Gain value | Information |
|----|-----------|--------------|--------------|
| 1 | Article 1 | 0.8 | High |
| 2 | Article 2 | 0.53 | Intermediate |
| 3 | Article 3 | 0.59 | Intermediate |
| | Rata-rata | 0.64 | Intermediate |

Based on the results of the data obtained in tables 2 and 3 above, it shows that in article 1 (Sunardi, 2021) at SMAN 1 Cigugur, the pretest average score was 60 and the posttest average score was 92, meaning there was an increase of 32. The n-Gain test results obtained an n-Gain value of 0.8, so the increase in student learning outcomes was included in the high category. In article 2 (Laisnima & Siregar, 2020) at YABT Christian High School, the average pretest score was 42.8 and the posttest average score was 73.3, meaning there was an increase of 30.5. The results of the n-Gain test obtained an n-Gain value of 0.53, so the increase in student learning outcomes was included in the medium category. In article 3 (Herwanti, 2021) in SMA Negeri Salatiga, the average pretest score was 52 and the posttest average score was 80.69, meaning there was an increase of 28.69. The results of the n-Gain test obtained an n-Gain value of 0.59, so the increase in student learning outcomes was included in the medium category. From the three articles, n-Gain values were obtained, respectively 0.8; 0.53; and 0.59 and the overall N-Gain average value is 0.64 or the increase in learning outcomes is in the medium category, meaning that learning using the STEM approach can improve student learning outcomes.

The results obtained by students after participating in learning activities with the STEM approach are in the form of knowledge and skills in the realm of thinking processes (cognitive), the domain of attitudes

(affective), and the realm of skills (psychomotor) (Nugraha & Ambiyar, 2018). The following is a graph of increasing learning outcomes with the three aspects of the 3 articles analyzed which have averaged each aspect of the assessment in cycles I and II.

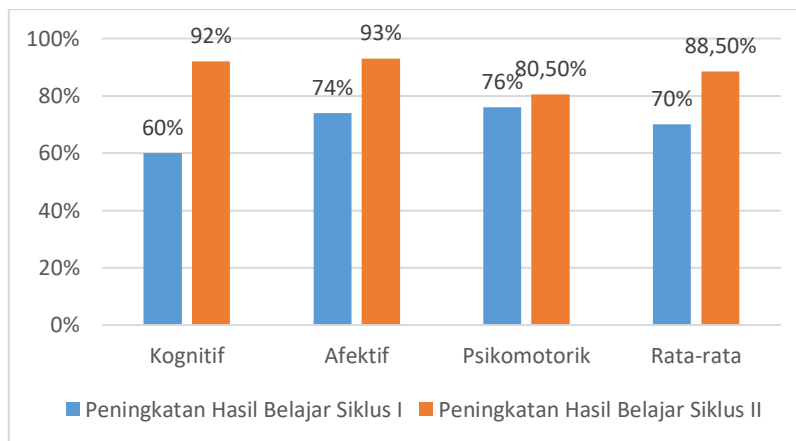


Figure 2. Percentage Diagram for Increasing Learning Outcomes from the Cognitive, Affective, and Psychomotor Domains

Based on the diagram above, it shows that of the three articles analyzed there was an increase in learning outcomes by applying the STEM approach to learning chemistry on Redox Reactions material. Of the three articles analyzed, the percentage of cognitive assessment in cycle I was 60% and in cycle II was 92%, meaning there was an increase of 32%. In the affective assessment, the percentage in the first cycle was 74% and the percentage in the second cycle was 93%, meaning there was an increase of 19%. In the psychomotor assessment, the percentage in cycle I was 76% and in cycle II was 80.5%, meaning there was an increase of 4.5%. Thus the average score obtained from increasing learning outcomes after applying learning with the Science, Technology, Engineering, and Mathematics (STEM) approach through three aspects of assessment in cycle I and cycle II is 79.25% in the medium category. The increase that occurred in the psychomotor assessment of the three articles was not too large compared to the cognitive and affective assessment, but the three aspects of the assessment both experienced a significant increase, meaning that the Science, Technology, Engineering, and Mathematics (STEM) approach in chemistry learning at redox reaction material can affect the improvement of learning outcomes because it makes it easier for students to understand the material.

The effectiveness of the STEM learning approach to improve learning outcomes is shown through the three articles analyzed and 17 other relevant articles. The STEM learning approach has the advantage of integrating science (including chemistry), technology, engineering, and mathematics to solve real-world problems. STEM education has five characteristics. namely 1). The STEM approach is centered on real-world problems. In STEM learning, students discuss and find solutions to real-world social, economic, and environmental problems. 2) the STEM approach is based on the Engineering Design Process (EDP). 3) the STEM approach teaches students to explore or explore openly. 4) the STEM approach involves students in productive teamwork. 5) The STEM approach applies the rigorous math and science content that students learn (Nugroho et al., 2019).

The STEM-based learning approach does not have steps for implementing learning or syntax, but STEM is an approach that is in accordance with a scientific approach which includes 5M learning patterns: asking, observing, reasoning, experimenting, and communicating (Yetti, 2021). STEM learning activities are carried out through the Engineering Design Process (EDP), which is the stage of designing a work. Engineering Design Process (EDP) is a problem-solving activity through developing ideas and products that require creative thinking and is carried out systematically to produce a product. EDP provides a flexible process that engages students from identifying a design problem or challenge to creating and developing a solution (Syukri et al., 2018). There are different variations of EDP based on expert opinion, with different steps or procedures. However, in general, EDP follows the following patterns or procedures: (1) identifying the problem, (2) gathering information, (3) identifying possible solutions (Identify Possible Solution), (4) making prototypes (Create Prototype), (5) evaluate and test (Evaluate or Test), (6) improve or modify the product (Refine), and (7) communicate (Communication) (Nurtanto et al., 2020)

The implementation of the Science, Technology, Engineering, and Mathematics (STEM) approach from the articles reviewed is by raising basic skills from one of the subjects taught in Class XII: redox reaction chemistry and electrochemistry. Redox substances were chosen because they are closely related to everyday

problems that can be presented in group discussion activities. In addition, simple experimental activities can also be carried out using redox reactive materials. Skills that can be developed are the ability to analyze, design, perform, conclude redox reactions, and present experimental results (Sumartati, 2020). An example of the application of the STEM approach based on one of the articles reviewed by including the basic skills of chemistry subjects on the topic of electroplating given in Class XII. This electroplating topic was chosen using the STEM approach. This is because it contains a number of knowledge or knowledge related to certain techniques that can be developed by considering mathematical calculations. Studying the STEM approach to redox reactions combines the EDP syntax with the following STEM aspects: (1) Science: The science knowledge gained by students consists of the concept of electrolysis using inert and inert electrodes through experiments. The principle of electroplating that occurs due to redox reactions in electrochemical cells. (2) Technology: This technology relates to electroplating tools and methods of processing electroplating result data. (3) Engineering or engineering: namely training students in the skills to engineer material components (solutions and metals) and electric currents to produce metal electroplating. (4) Mathematics: mathematics in this lesson is in the engineering process of designing experiments, processing experimental data such as calculating metal mass, solution concentration, outer metal coating, time used and electric current, and calculating electroplating production costs (Rosadi et al., 2019)

The average n-Gain value of the 3 articles analyzed was 0.64 and the increase in learning outcomes was included in the medium category. Through this category, the STEM approach can be applied as an effort to improve student learning outcomes in chemistry learning. The Science, Technology, Engineering, and Mathematics (STEM) approach has been widely used in learning. Then, the average result obtained from increasing learning outcomes through three aspects of assessment in cycle I and cycle II is 79.25% which is included in the good category. This shows that the STEM approach in learning chemistry on redox material can affect the improvement of learning outcomes because it makes it easier for students to understand the material. Therefore, the application of the STEM (Science, Technology, Engineering, and Mathematics) approach is able to increase knowledge skills, apply knowledge to solve problems, encourage students to create something new, in fact it can affect learning outcomes.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Based on the results of the analysis by reviewing 3 articles and several other related articles, it can be concluded that the Science, Technology, Engineering, and Mathematics (STEM) learning approach plays a role in significantly improving student learning outcomes in chemistry learning material for class XII Redox Reactions with an average increase learning outcomes through the n-Gain test pretest and posttest results of 0.64 in the medium category and the average percentage of learning outcomes is 79.25%. So, through these categories the Science, Technology, Engineering, and Mathematics (STEM) approach is effectively used to improve student learning outcomes in learning chemistry redox reaction material.

B. Recommendations

The author's suggestions for further review research regarding the Science, Technology, Engineering, and Mathematics (STEM) approach include: use other chemistry subjects to see the effect of using the Science, Technology, Engineering, and Mathematics (STEM) approach to increasing learning outcomes such as subject discussion of thermochemistry, colligative properties of solutions, chemical equilibrium, and so on, use more than three sample articles reviewed to add to and strengthen the results of the review regarding the effect of using the Science, Technology, Engineering, and Mathematics (STEM) approach.

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