JoSSEd
Journal of Science and Science Education
ISSN: 2774-1869 eISSN: 2774-2105

Application of Chemistry Modules with a STEM Approach to Improve Student Activity and Learning Outcomes in Buffer Solution Material

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Received: September 18, 2025
Revised: March 17, 2026
Accepted: April 28, 2026
Published: April 30, 2026

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DOI: 10.29303/jossed.v7i1.14051

Abstract: The limited teaching materials used by educators are a factor in the quality of learning that will have an impact on student activity and learning outcomes. So this study was conducted to measure the increase in activity, learning outcomes and student responses to the use of chemistry modules with a STEM approach on buffer solution material at SMA Negeri 1 Sibolga. This type of research is quantitative research. The data collected were in the form of learning outcome test instruments and non-tests in the form of learning activity observation sheets and student response questionnaires. The results of the study were that there was an average score of increased learning outcomes for students who were taught using a chemistry module based on a STEM approach on buffer solution material of 0.79 with a high category, an average score of student learning activities when learning using a chemistry module based on a STEM approach on buffer solution material of 79.35 with an active category, and an average score of student responses to the use of a chemistry module based on a STEM approach on buffer solution material of 87.39% with a very positive category. Based on the data obtained in this study, it was concluded that a chemistry module with a STEM approach on buffer solution material can increase student activity and learning outcomes and have a positive impact on students in learning.

Keywords: Chemistry Module; Learning Ativities; Learning Outcomes; STEM Approach; Student Response.

Introduction

School is a formal educational institution, as a place where teaching and learning takes place with all the facilities and infrastructure as well as environmental conditions that support the ongoing teaching and learning activities (Anisa, F., & Yulianto, 2015). Based on the regulation of the Minister of Education and Culture Number 022 of 2013 concerning the standards of the education process, the learning process in educational units is carried out interactively, inspiringly, pleasantly, challengingly, motivating students to participate actively, and is able to provide sufficient space for initiative, creativity, and independence according to the talents, interests and physical development of students (Rasmanah et al., 2024). The success of the learning process at school is influenced by many factors, including teachers, students, curriculum, learning environment, learning resources and others (Simatupang, 2021). Common problems faced in learning at school tend to transfer knowledge completely from the teacher's mind to the student's mind, so that in learning the teacher is more active than the student (Karyawati et al., 2022). Students are not trained enough to discover knowledge for themselves, so that students' interest and attention tend to decrease in learning, which has an impact on low learning outcomes (Riyanto & Betaubun, 2019). This can be proven based on Firdaus et al. (2022) research which states that the exam scores for the chemistry subject on the material of buffer solutions are still far below the completion limit, with an average exam score of 50 at MA Swasta Darul Aman, at MA Negeri 4 Aceh of 65.75, and at MA Swasta Darul Insan of 73.83. In learning the material on buffer solutions, 68.3% of students experienced learning difficulties (Muderawan et al., 2019).

How to Cite:
Manalu, E., & Silaban, S. (2026). Application of Chemistry Modules with a STEM Approach to Improve Student Activity and Learning Outcomes in Buffer Solution Material. *Journal of Science and Science Education*, *7*(1), 81–86. https://doi.org/10.29303/jossed.v7i1.14051

Chemistry is a new subject that is taught comprehensively in high school (Prayunisa, 2022). In learning chemistry, students are less enthusiastic. This is because chemistry is considered a difficult subject, which sometimes makes students not want to study chemistry further (Budiariawan, 2019). To attract students' interest in learning, it is hoped that learning will be carried out by actively involving students so that the learning process can take place optimally (Rahmawati et al., 2019). Buffer solution is one of the materials in chemistry (Genes et al., 2021). The concept of buffer solutions is a chemical concept that is understood sequentially and in stages, where when students understand the basic knowledge, students are able to study the next material. The basic concepts of buffer solution material include chemical balance and acid bases (Riswana & Rusmini, 2020).

Students who are less involved in the learning process can have an impact on the lack of learning activities and low learning outcomes obtained. One effort that can be made to overcome this problem is to apply the STEM (science, technology, engineering, and mathematics) approach to the learning process (Irmita, 1970). The STEM approach is a discipline that is closely related to each other. The STEM approach in learning is expected to produce meaningful learning for students through the systematic integration of knowledge, concepts, and skills (Aulya et al., 2021). As an approach, STEM is an approach to education where science, technology, engineering, and mathematics are integrated into the educational process focused on solving real-life problems in everyday life as well as in professional life (Davidi et al., 2021). In using the STEM approach in learning, students not only gain knowledge but also learn how to apply the knowledge they gain to solve everyday life problems related to the fields they have studied at school (Aulia Khairunnisa et al., 2023). In addition to the use of the STEM approach in chemistry learning, there are several factors that can affect the quality of learning and the achievement of learning objectives. One of them is the use of learning media in the form of learning modules (Hulu & Simorangkir, 2022).

Learning modules are one of the learning media that teachers can use in implementing the learning process in the classroom (Putra & Iryani, 2020). Modules are print-based learning media used by teachers and students so that they can increase effectiveness and efficiency in learning (Al Azka et al., 2019). In using the module, it is hoped that students can develop their knowledge, thinking skills and motor skills through direct interaction in the form of activity-based learning activities (Hakim et al., 2020). Learning modules are used so that the learning process regarding a topic can take place systematically, operationally and in a directed manner (Kosasih, 2016). The module has 5 features or characteristics, namely self-instructional, self-contained, stand alone, adaptive, user friendly (Heni Jusuf & Ahmad Sobari, 2021). Learning activities are student activities that show changes for the better in students, as seen through interactions between individuals or individuals with the environment (Nuraini et al., 2018). Various types of learning activities include visual activities, oral activities, writing activities, mental activities and emotional activities. Learning outcomes are the abilities possessed by students as a result of changes in behavior or teaching methods used by teachers (Rahim et al., 2023). Learning outcomes can also be interpreted as certain abilities or competencies, both in terms of affective, cognitive and psychomotor, which are mastered or achieved by students when participating in learning (Harahap et al., 2022). Student learning outcomes are essentially changes in behavior as a result of learning in a broader sense covering 3 areas, namely cognitive, affective and psychomotor (Maulidiyah & Setyawan, 2024).

Based on the results of Antara (2022) research at SMA Negeri 1 Semapura, it is known that chemistry learning in class is still done conventionally. The learning process is still centered on concepts written in books, so students tend to only memorize concepts rather than understand concepts. This is in accordance with the problems found in the implementation of chemistry learning at SMA Negeri 1 Sibolga, so the researcher intends to provide a solution to the existing problems, the teaching materials used by teachers, especially chemistry teachers, are still less varied. Where the teaching materials used are textbooks and LKS books given to students. This can be a factor in the quality of learning that is less effective which has an impact on the activities and learning outcomes obtained by students. This is in accordance with the research of Siregar & Silaban (2023) and research by Susanti (2018) regarding the use of chemistry modules based on the STEM approach which can improve student learning outcomes in chemistry material.

Method

This research was conducted at SMA Negeri 1 Sibolga located at Jalan Sutoyo Siswomiharjo No. 1 Sibolga, North Sibolga District, Sibolga City, North Sumatra. This research was conducted in the even semester of the 2024/2025 academic year. The subjects of this study were students of class XI MIPA 6 of SMA Negeri 1 Sibolga in the 2024/2025 academic year. This study used a one-group design. Which uses one class as an experimental class. The data used in this study were improvements in student learning outcomes, student learning activities, and student responses to learning modules based on the STEM approach in learning buffer solution material. Before the questions were tested on

students, the questions were first validated in terms of content, and tested on the upper class to determine the extent to which the instrument had met the prerequisites for validity, reliability, difficulty level, discrimination, and distractor test.

Research Design

Research design is a design regarding the entire process required in planning and implementing research (Ardianto & Putra, 2022). The research design used in this study is a one-group pretest-posttest design. In which this study uses one class as an experimental class. By providing a pretest, treatment, and at the end a posttest is carried out to measure the increase in learning outcomes obtained by students after the treatment is carried out.

Research Instrumens

Research instruments are very essential components in research because they function to collect data that is relevant to the research objectives. Through the evaluation process, we can collect relevant data related to the research object (Fauziyah et al., 2023). The instruments used by the researcher were test instruments in the form of multiple-choice questions which were questions during the pretest and posttest, non-test instruments in the form of observation sheets of student learning activities filled out by observers at each meeting and student response questionnaires to the STEM-based chemistry module used in learning buffer solution material which were given to students at the end of the meeting on the buffer solution material.

Result And Discussion

Student Learning Activities

Observation assessment of student learning activities is carried out at each observer meeting. From the results of calculating the average score of student learning activities, the percentage of student learning activities when learning is carried out using a STEM-based chemistry module is 79.3% with an active category. This is in accordance with research by Suryani et al. (2020) which found that the average student activity in chemistry learning using a STEM-based approach module obtained an average learning activity value of 79.77, which is included in the active category. The percentage of student learning activities during learning using the STEM-based chemistry module on buffer solution material can be seen in Table 1.

Table 1. Student Learning Activity Data

Meeting	average learning activity (%)	Criteria
1	68.82	Active
2	78.82	Active
3	90.39	Very active
Average	79.35	Active

Increasing Student Learning Outcomes

At the beginning of the learning, the researcher conducted a pretest to see the initial abilities of the students and at the end of the learning the researcher conducted a posttest to see the learning outcomes obtained by the students after learning using the STEM-based chemistry module on the buffer solution material. Based on the pretest and posttest data, the N-Gain test was conducted to see the increase in learning outcomes. The average N-gain value was 0.79 with a high category. So it can be said that learning using the STEM-based chemistry module on the buffer solution material can improve student learning outcomes. The data obtained is in accordance with the research of (Laisnima & Siregar, 2020) that the chemistry module based on the STEM approach used in chemistry subjects can improve student learning outcomes with an N-Gain score of 0.53 in the moderate category.

In the study by Manurung & Zubir (2023) student learning outcomes showed an increase in student learning outcomes in chemistry learning using e-modules based on the STEM approach, with an average pretest score of 39.83 and an average posttest score of 82.5. In the research of Gurusinga & Eddiyanto (2025) there was an increase in the learning outcomes of students who were given treatment using the Project Based Learning-based STEM e-module on the chemical equilibrium material in experimental class 1, increasing by 71.42%; experiment 2 by 70.69%; experiment 3 by 68.63%. With the N-Gain effectiveness criteria in the experimental class, it is quite effective, so it can be concluded that the use of the PjBL-based STEM e-module on the Chemical Equilibrium material can improve student learning outcomes. N-Gain data can be seen in Table 2.

Table 2. N-Gain Score Acquisition

Score *N-Gain*	Category	Frequency	Average *N-Gain*	Information
$0.70 \leq g \leq 1.00$	Tall	32	0.79	Tall
$0.30 \leq g < 0.70$	Currently	2		
$0.00 < g < 0.30$	Low	0		
$g = 0.00$	No increase occurred	0		
$-1.00 \leq g < 0.00$	Decline	0		
Amount		34		

Student Response

Student response questionnaires were used to determine students' responses to the use of STEM-based chemistry modules in learning on buffer solution material. From the calculation of the results of the student response questionnaire, the average score of student responses to the use of STEM-based chemistry modules in learning was 87.39% with a very positive category. This is in accordance with research by Nurhayati et al. (2021) which found that students' responses to the use of STEM-based chemistry e-modules showed a positive response of 86.2% with a very positive category. Data obtained in the research of Izzania et al. (2024) e-teaching modules used in STEM-based learning approaches produced a score of 58.7 or a percentage of 85% based on student responses, this shows that e-teaching modules with STEM-based learning models on chemical material. In the research of Gultom & Amdayani (2023) it was found that the response of class students to the STEM-based chemistry e-Module on the reaction rate material obtained an average kappa moment value of 0.85 with the category of Very High. The STEM (Science, Technology, Engineering, and Mathematics) based module on Thermochemistry material is very valid for use in high school, marked by the average percentage score of 11 validators of 90.3% and received a very good response from students, marked by the percentage score of 92.7%, so it is highly recommended for use by students (Budiariawan, 2019). Student response data can be seen in Table 3.

Table 3. Student Response Data

Criteria	Frequency	Percentage (%)	Average (%)
Very positive	19	55.88	87.39 (Very positive)
Positive	15	44.12	
Less positive	0	0.00	
Not positive	0	0.00	
Amount		34	100%

Conclusion

The use of STEM-based chemistry modules on buffer solution material is good for use in learning that has been seen based on the increase in student learning outcomes, student learning activities and student responses to the use of the module.

Acknowledgments

The researcher would like to thank the Principal and Chemistry Teachers of SMA Negeri 1 Sibolga for the opportunity given to conduct this research. Gratitude is also expressed to all parties who have supported the researcher during this process.

Author Contributions

This script was written by two people: E. M., and S. S.

Funding

This research did not receive any external funding.

Conflicts of Interest

There is no conflict of interest.

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