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Implementation of STEM-Based PBL with Quizizz and Mentimeter Media on Student Learning Outcomes

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Abstract: *An effective learning model and appropriate media are essential to optimize students' understanding and learning outcomes. This study aims to find out if there are differences in student learning results when using the Problem-Based Learning STEM model with Quizizz media compared to Mentimeter media. This study uses a quantitative method with an experimental design and a sample selected through random sampling, consisting of two experimental groups taught using the STEM-based Problem-Based Learning model with different media, namely Quizizz and Mentimeter. The research instrument is a validated multiple-choice learning outcome test, and the data are analyzed using normality and homogeneity tests, as well as hypothesis testing with paired sample t-test and independent t-test. The paired sample t-test results showed a significant improvement in learning outcomes before and after the treatment in both classes (significance 0.000 ≤ 0.05), while the independent t-test results indicated a significant difference in learning outcomes between the two experimental classes (significance 0.000 ≤ 0.05). The implementation of the STEM-based Problem-Based Learning model with the help of digital learning media (Quizizz and Mentimeter) is effective in improving students' learning outcomes on stoichiometry material; however, Quizizz proved to be superior to Mentimeter in this study.*

Keywords: *learning media; problem-based learning; STEM; learning outcomes; stoichiometry*

INTRODUCTION

The development of science and technology demands an increase in the quality of education (Talaohu, 2022). Chemistry is a part of science (IPA) that studies natural phenomena in everyday life. Some of the characteristics of chemistry subjects include: (1) most of the concepts are abstract, hierarchical, and structured; (2) it is a science for solving problems and describing facts and events (Fauzannur et al., 2022). Stoichiometry material is one of the chemistry materials that is considered difficult by students because Stoichiometry has material that is characterized by many calculations, concepts and formulas (Purba et al., 2021). According to (Rahayu & Yerimadesi, 2022) stated that the reason students consider stoichiometry to be difficult material is because the material is difficult for students to understand due to too many formulas and calculations. The low learning outcomes experienced by students in stoichiometry material can be caused by students' mathematical learning abilities, such as the role of teachers as learning activity

guides, learning strategies applied, facilities and infrastructure, curriculum, and learning environment (Lider, 2022).

In this context, teachers are expected to design learning activities that can develop student competencies, both in the cognitive, affective, and psychomotor domains. Learning strategies that focus on students and create a pleasant atmosphere are important to improve student learning outcomes in chemistry subjects. As the right solution, researchers chose a problem-based learning model (PBL), with a Science, Technology, Engineering, and Mathematics (STEM) approach, to increase student motivation in developing science and mathematics skills, as well as to improve problem-solving skills (Pujiati, 2022). During the learning process, in addition to choosing the right model, media variations also need to be applied. Learning a chemical concept will be easy to understand and remember by continuing to repeat the learning or assisted by a media (Khairunnisa et al., 2022).

Based on observations and interviews conducted at SMA Swasta Sultan Iskandar Muda Medan, it was found that teachers still frequently use conventional methods that limit student engagement because the learning process remains teacher-centered. As a result, students often have difficulty focusing during chemistry lessons, which negatively affects their learning outcomes. Additionally, the use of digital media such as Quizizz and Mentimeter is still rare in teaching stoichiometry. To address these issues, implementing a student-centered learning model supported by interactive media is recommended. This approach aligns with the findings of (Tambunan et al., 2024), which show that the use of problem-based learning combined with media significantly improves student learning outcomes.

Previous studies generally only examined the use of a single digital media, such as Quizizz or Mentimeter, without directly comparing their effectiveness within one experimental design in the context of PBL STEM. Meanwhile, the application of PBL with Quizizz has been proven to improve student learning outcomes (As'ad et al., 2024), Mentimeter encourages better interaction and understanding through its interactive learning features (Malia et al., 2023). Therefore, research comparing both media directly within the PBL STEM model is needed.

Based on this background, researchers are motivated to conduct research entitled "Comparison of Quizizz and Mentimeter Media in STEM-Based PBL Model on Students' Learning Outcomes". Theoretically, the results of this study are expected to be useful for the development of science, especially in the utilization of the STEM Problem-Based Learning learning model.

LITERATURE REVIEW

A learning model is a conceptual framework that describes learning procedures from beginning to end systematically to achieve learning objectives and serves as a guideline for educators in carrying out learning activities. Learning models have a broader scope of approaches, strategies, methods, techniques, and learning tactics (Samala et al., 2022).

The use of the right learning model is one of the important things in teaching and learning activities to convey knowledge to students effectively (Dibyantini & Azaria, 2020). A good learning model must be adjusted to the characteristics and conditions of the students (Harefa, 2023).

Problem-Based Learning is a constructivist learning model oriented towards student-centered learning that is able to foster a creative, collaborative spirit, metacognitive thinking, develop high-level thinking skills, increase understanding of meaning, increase independence, facilitate problem solving and build teamwork (Hartatik, 2022). Problem-Based Learning (PBL) is a learning model that uses contextual problems to be solved using PBL syntax. The PBL syntax is: (1) orientation towards the problem, (2) organizing students, (3) guiding individual and group investigations, (4)

developing and presenting work results, and (5) analyzing and evaluating the problem-solving process (Noresti et al., 2023).

The Problem-Based Learning model is a learning model whose learning process is based on problems that require students to work together in groups to gain knowledge through solving the problems presented (Dalimunthe & Ginting, 2022)

The PBL model can be integrated with the science, technology, engineering mathematics (STEM) approach. STEM is an effective way to facilitate and maintain the integration of science, technology, mathematics, and engineering (C. D. Putri et al., 2020). The goal of STEM education is to improve students' understanding of learning materials by applying Science, Technology, Engineering, and Mathematics, besides that the most important thing is for students to be able to apply this knowledge to solve complex problems by developing high-level thinking skills; prepare for the needs of 21st century human resources; and develop competencies in the STEM field. Learning with a STEM approach tends to improve the quality of learning (Septiani et al., 2020).

An active, innovative learning model enhances student outcomes and classroom engagement, aligning with constructivist theory and prior research emphasizing student involvement. The implementation of Problem-Based Learning combined with electronic media such as edugames can significantly enhance students' science literacy and academic performance (Sumarsih et al., 2024).

Learning media is a tool that can be used to help the learning process be more effective and optimal. At this time, the learning process is not limited only to books and blackboards, because currently, many learning media can be used by teachers (Fadilah et al., 2023). Interactive learning media is everything related to software and hardware that can be used as an intermediary to convey the contents of teaching materials from learning sources to learners with learning methods that can provide feedback to users from what has been input into the media (Putri et al., 2022).

Quizizz is one of the media innovations in learning evaluation activities. Many features can be used, such as multiple-choice questions (Pusparani, 2020). The advantages of the Quizizz media are that it makes it easier for students to explore the main learning material, the selection of media is very interesting for students because it allows students to play while learning by using the facilities available in Quizizz, also motivates and improves student learning outcomes, and can be used by teachers in reviewing their performance with learning outcomes (Tiana et al., 2021)

Mentimeter is one of the platforms that can be used as an interactive learning medium. Mentimeter is used as a learning medium because Mentimeter can provide space for discussion, thus increasing the role of students in learning activities and making it easier for students to discuss and contribute to learning activities (Putri & Puspasari, 2023). In making learning media, mentimeter offers several features in the quick slide section to create interesting presentations, such as the heading feature as a large title in delivering the material, the paragraph feature as the content of the material to be presented by the teacher, the bullets feature as important points or numbering of content components that do not have to be in order, the image feature as adding images of the material to be explained by the teacher, and the number feature as numbering and the video feature as adding videos to explain the material to be presented more clearly (Nasution & Anas, 2022).

Learning outcomes are a process to see the extent to which students can master learning after participating in teaching and learning activities, or the success achieved by a student after participating in learning activities marked by certain numbers, letters, or symbols agreed upon by the education organizer (Medianto et al., 2023). Student learning outcomes are achieved by students academically through exams and assignments,

actively asking and answering questions that support the acquisition of these learning outcomes (Dakhi, 2020).

Learning outcomes are shaped by influences originating both inside and outside the learner. Internal influences include the individual's physical condition and psychological state, while external influences involve elements from the learner's environment, such as family background, school setting, and community factors (Panggabean et al., 2023).

METHODS

Research Design

The research design used in this study is the *Pretest-Posttest One Group Design*. In this study, two experimental groups were given a pretest, and both experimental groups received different treatments (Sugiyono, 2017). Experimental group I used the Problem-Based Learning (PBL) STEM learning model with Quizizz media, and experimental group II used the Problem-Based Learning (PBL) STEM learning model with Mentimeter media, and then ended with a posttest for each experimental class. The following is a table of the research design used.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment I	T1	X	T2
Experiment II	T1	Y	T2

Population and Sampling Technique

This research was conducted at Sultan Iskandar Muda High School, Medan, located at Tengku Amir Hamzah Street, Pekan I Gg. Medan Sunggal District, Medan City, North Sumatra 20128. This research will be conducted in the 2024/2025 academic year. The population in this study was students of class XI IPA of SMA Swasta Sultan Iskandar Muda Medan in the 2024/2025 academic year, consisting of 4 classes with an average number of students of 40 in each class.

The sampling technique used in this study was the random sampling technique. The sample used in this study was class XI-1 as the experimental class I taught with the Problem Based Learning (PBL) STEM model using Quizizz media (X) and class XI-2 as the experimental class II was a class taught with the Problem Based Learning (PBL) STEM model using Mentimeter media (Y).

Instrumentation and Validation

The research instrument is a test of student learning outcomes in chemistry subjects on the subject of Stoichiometry. The test used in this study is a multiple-choice objective test of 20 questions, with each question item consisting of five answer choices (a, b, c, d, and e), and there is only one most appropriate answer choice.

Before the test of student learning outcomes is given to students, the test is first validated. After the test of learning outcomes is valid, the test of learning outcomes is given to students who are included in the research sample. The test of learning outcomes is carried out twice, namely, pre-test and post-test. Quizizz and Mentimeter learning scenarios were validated by media experts for appropriateness, clarity, and engagement.

Data Collections

The data collection began with administering a pretest to both groups to evaluate their baseline knowledge. After that, treatment is given, namely in experimental class I, treatment is carried out with the *Problem-Based Learning* (PBL) STEM learning model using *Quizizz* Media, and in experimental class two, treatment is carried out with the *Problem-Based Learning* (PBL) STEM learning model using Mentimeter Media. Then a posttest is carried out in both experimental classes.

In this study, the teacher presented problems using Quizizz as the digital medium in Experimental Class I and Mentimeter in Experimental Class II. The learning process was conducted over five

sessions, with each session lasting 2 x 45 minutes (90 minutes). The teacher plays several important roles in the learning process. As a facilitator, the teacher guides and directs students in understanding and solving the given problems. Acting as a motivator, the teacher encourages students to actively participate in discussions and explore solutions. In the role of technology mediator, the teacher assists students in using Quizizz (for Experimental Class I) and Mentimeter (for Experimental Class II) to support the learning activities. Finally, as an evaluator, the teacher assesses student progress through pretests, posttests, and observations of student activities during the lessons.

Data Analysis

Data analysis techniques used include: (1) Normality Test, (2) Homogeneity Test, and (3) Hypothesis Test. The hypothesis test conducted is the significance T-test. The hypothesis test used in this study is a two-tailed t-test.

The flowchart of the research can be seen in figure 1.

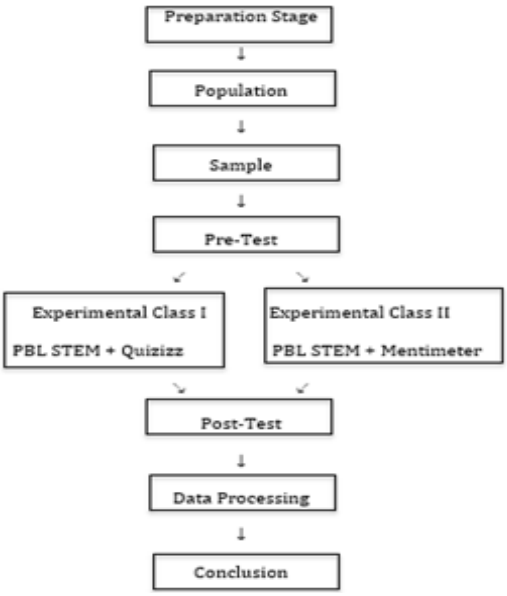

Figure 1. The reseach flowchat

RESULT AND DISCUSSION

In this study, learning outcomes were obtained from a test instrument consisting of 20 multiple-choice questions with 5 answer choices. Students were given questions at the end of the learning process. This treatment was carried out in experimental class I and experimental class II with the same number of questions. Data obtained from student learning outcomes can be seen in **table 2**.

Table 2. Average Data on Student Learning Outcomes

Treatment	Experiment Class 1	Experiment Class 2
Pre-Test	44,02	31,52
Post-Test	80,65	64,02

In Experiment Class 1, the average score increased from 44.02 to 80.65, showing an improvement of 36.63 points. Meanwhile, in Experiment Class 2, the average score rose from 31.52 to 64.02, reflecting an improvement of 32.5 points. This shows an increase in student learning outcomes after the application of the *Problem-Based Learning* STEM model with *Quizizz* Media in experimental class I and Mentimeter Media in experimental class II. The test results showed a significant effect on the average pretest and posttest of both classes. The increase in student learning outcomes in experimental class I using *Quizizz* media was higher than in experimental class II using Mentimeter media.

Quizizz media is able to have a greater influence on student learning outcomes because it integrates game-based elements and interactive features that significantly enhance student engagement, motivation, and interest in learning. According to recent research, the use of Quizizz in classroom settings leads to substantial improvements in various indicators of learning interest, such as happiness, involvement, attention, and overall engagement. This is supported by learning theories like constructivism and behaviorism, which emphasize the importance of active participation and immediate feedback in the learning process.

From a constructivist perspective, Quizizz allows students to actively construct knowledge through interactive quizzes, while the instant feedback helps reinforce learning and correct misconceptions in real time. The competitive and playful aspects of Quizizz also align with behaviorist principles by

providing positive reinforcement through points, badges, and rankings, which increase motivation and drive students to participate more actively (Mesterjon et al., 2024).

Normality Test

The normality test was conducted using the SPSS 21 *Kolmogorov-Smirnov* test with a significance level of 0.05. Data is said to be normally distributed if the sig value > 0.05, and vice versa if the sig value ≤ 0.05; then the data is not normal.

Table 3. Normality Results on Student Learning Outcomes

Class	Treatment	Sig (Kolmogorov - Smirnov)
Experiment I	Pre-test	0,056
	Post-test	0,051
Experiment II	Pre-test	0,053
	Post-test	0.124

The normality test results for both pre-test and post-test scores in Experiment Class I and Experiment Class II all show significance values greater than 0.05, indicating that the data are normally distributed. This confirms the suitability of the data for parametric statistical analysis.

Homogeneity Test

The homogeneity test is used to test whether the distribution of data from two or more variants comes from a homogeneous population or not, namely by comparing two or more variants. If the data analyzed is homogeneous, then parametric statistics can be continued. This study uses the *Levene Statistic* homogeneity test using SPSS version 21.

Table 4. Results of the homogeneity test of student learning outcomes

	Levene Statistic	df1	df2	*Sig.*
Learning Outcomes	1,860	3	180	0,138

Based on table 4, it shows that the significance value of the learning outcome data for students in experimental class I and experimental class II is 0.138 > 0.05, which means that the student learning outcome data is homogeneous.

Hypothesis Test

Hypothesis I

The data was statistically tested using SPSS version 21, and hypothesis testing was carried out after knowing whether the data was normally distributed and homogeneous. In hypothesis I, a *Paired Sample T-Test* was carried out with a 95% confidence level (α = 0.05). The test criteria are if the significance ≤ α (0.05), then Ha is accepted and H0 is rejected. Meanwhile, if the significance > α (0.05), then Ha is rejected and H0 is accepted. The data used for this hypothesis test is the pre-test and post-test value data in experimental class I. The hypothesis test results can be seen in table 5.

Table 5. Results of Hypothesis I Test Analysis Student Learning Outcomes

	Mean	df	*Sig. (2-tailed)*	*Std. Deviation*
Learning Outcomes	-36.63	45	0,000	9.312

Table 5 shows that the results obtained from the hypothesis test I are the Sig.(2-tailed) value of 0.000 ≤ α (0.05). It is concluded that there is a significant difference in student learning outcomes before and after being taught with the *Problem-Based Learning* STEM learning model using Quizizz media.

The average pre-test and post-test scores in experimental class I increased. This is in line with research conducted by (Arrahim et al., 2022) showing that the application of quizizz learning media as an aid in the application of learning models or methods has been proven to improve learning outcomes. The application of quizizz is the main solution or aid for models or methods that are utilized such as the Quantum Model, Problem Based Learning Model, Contextual Model, Blended Learning Model, and Scientific and Cooperative Learning Methods. The application of Quizizz media at the end of

learning can make learning fun and make students always enthusiastic about learning. in addition, the application of this Quizizz media can motivate students in doing exercises because the ranking can be shown for each quiz given. This can eliminate students' boredom in learning, provide a pleasant learning environment, and improve students' learning outcomes. The increase in student learning outcomes shows a difference in student learning outcomes before and after being taught with the *Problem-Based Learning* STEM learning model using Quizizz media.

Hypothesis II

The data was statistically tested using SPSS version 21, and hypothesis testing was carried out after knowing whether the data was normally distributed and homogeneous. In hypothesis II, a *Paired Sample T-Test* was carried out with a 95% confidence level (α = 0.05). The test criteria are if the significance ≤ α (0.05), then Ha is accepted and H0 is rejected. Meanwhile, if the significance > α (0.05), then Ha is rejected and H0 is accepted. The data used for this hypothesis test is the pre-test and post-test value data in the experimental class II. The hypothesis test results can be seen in table 6.

Table 6. Results of Hypothesis II Test Analysis Student Learning Outcomes

	Mean	df	*Sig. (2-tailed)*	*Std. Deviation*
Learning Outcomes	-32,50	45	0,000	9,647

Hypothesis test II aims to determine the difference in student learning outcomes before and after being taught with the *Problem-Based Learning* STEM learning model using Mentimeter media. Hypothesis one was tested in the experimental class II using the paired sample t-test. The results obtained were a Sig. (2-tailed) value of 0.000. ≤ α (0.05). Based on the results obtained, it can be concluded that there is a significant difference in student learning outcomes before and after being taught with the *Problem-Based Learning* STEM learning model using Mentimeter media. This can also be seen from the increase in the average pre-test and post-test scores in experimental class II.

The results obtained are by research conducted by (Nurhasanah et al., 2024) showing that interactive Mentimeter media makes students learn more actively during the learning process. Students are directly involved in using the media. Another benefit felt from the Mentimeter media is that students are able to build their initial knowledge about the material being studied. This can improve student learning outcomes.

Hypothesis III

Data analysis was tested statistically using SPSS version 21, and hypothesis testing was carried out after determining whether the data were normally distributed and homogeneous. In hypothesis III, an *Independent T-Test* was carried out with a 95% confidence level (α = 0.05). The test criteria are if the significance ≤ α (0.05), then Ha is accepted and H0 is rejected. Meanwhile, if the significance > α (0.05), then Ha is rejected and H0 is accepted. The data used for this hypothesis test is the pre-test and post-test value data in experimental class I and experimental class II. The hypothesis test results can be seen in table 7.

Table 7. Results of Hypothesis III Test Analysis Student Learning Outcomes

	t	df	*Sig. (2-tailed)*	Mean Difference
Learning Outcomes	8,644	90	0,000	16,630

The results of the third hypothesis test using the Independent t-test in both classes showed a Sig. (2-tailed) value of 0.000 ≤ α (0.05). Thus, in the third hypothesis, it can be concluded that Ha is accepted, meaning that there is a significant difference in student learning outcomes using Quizizz Media and Mentimeter Media with the STEM *Problem-Based Learning* model on the subject of Stoichiometry. Students who are taught using the STEM-based *Problem-Based Learning* (PBL) learning model with Quizizz media show a

higher increase in learning outcomes compared to students who are taught using the STEM-based *Problem-Based Learning* (PBL) learning model with Mentimeter media.

Learning outcomes represent the extent to which students achieve educational objectives through participation in teaching and learning activities. These outcomes are manifested as behavioral changes across cognitive, affective, and psychomotor domains (Ramadhana & Sutiani, 2023). According to (Siregar & Simatupang, 2020) learning outcomes manifest through various dimensions such as knowledge acquisition, comprehension, skill development, emotional growth, social interactions, physical abilities, ethical values, character formation, and attitudes. When an individual engages in learning activities, changes can be observed in one or more of these behavioral aspects as a direct consequence of the learning process.

Students who learn using the STEM-integrated PBL approach show a significant increase in learning motivation. They feel more interested and motivated because the problem-based learning is relevant to everyday life, which in turn enhances their engagement and participation in the learning process. The integration of STEM in PBL not only boosts motivation but also improves students' learning outcomes, particularly in understanding physics concepts, the respiratory system, and science literacy in general. Research shows that students who participate in PBL-STEM learning achieve higher scores compared to those taught using traditional methods. This indicates that this approach is effective in enhancing the quality of learning and academic performance (Andriani et al., 2024).

The use of the STEM-based *Problem-Based Learning* (PBL) learning model with Quizizz media can attract students' interest in the learning process and encourage improved learning outcomes compared to before. This is in line with research conducted by (Wahyuni et al., 2023) showing that the use of Quizizz media can improve learning outcomes, and Quizizz media provides students with a better understanding, which has a positive impact on their learning outcomes. This is because the Quizizz learning media is more interactive and attracts students' attention. The features in the Quizizz media are also more numerous than the Mentimeter media, so the Quizizz media attracts students' attention more.

CONCLUSION

This study demonstrates that the use of Quizizz and Mentimeter media significantly improves student learning outcomes in chemistry. The findings confirm the hypothesis that interactive, game-based learning tools enhance student engagement and achievement more effectively than traditional methods. Quizizz, in particular, showed a greater impact, likely due to its ability to provide immediate feedback and foster a competitive yet enjoyable learning environment.

Beyond confirming the effectiveness of these media, the study's results have important implications for educational practice and the development of teaching strategies. Educators can leverage Quizizz and Mentimeter to create more dynamic and interactive chemistry lessons that motivate students and facilitate deeper understanding. Incorporating such technology-driven approaches supports the advancement of science and technology education by aligning with contemporary learning theories and digital literacy demands.

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