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Implementation of Blended Learning-Based STEM-PjBL Learning Model Redox on and Electrochemical Materials

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Abstrak

Redoks dan elektrokimia merupakan materi yang dianggap sulit oleh siswa. Salah satu kesulitan yang dialami siswa adalah dalam menyetarakan reaksi redoks dengan menggunakan metode bilangan oksidasi. Kondisi ini diperparah dengan kegiatan belajar yang harus dilakukan dari rumah sehingga mengakibatkan rendahnya motivasi dan hasil belajar siswa. Oleh karena itu, diperlukan metode pembelajaran yang inovatif, namun tetap efektif jika diterapkan secara daring. Salah satu model pembelajaran yang dapat diterapkan adalah STEM-PjBL yang berbasis blended learning. Tujuan penelitian adalah untuk mengetahui perbedaan motivasi dan hasil belajar siswa yang diajar menggunakan model pembelajaran STEM-PjBL berbasis blended learning dengan model pembelajaran ceramah. Penelitian ini merupakan penelitian quasi eksperimen dan menggunakan desain penelitian post test only control design. Populasi penelitian adalah siswa kelas XII IPA SMAN 5 Malang tahun ajaran 2021/2022. Sampelnya adalah kelas XII G dan H yang berjumlah 63 orang yang diambil secara purposive sampling. Data yang dikumpulkan adalah hasil belajar siswa meliputi aspek kognitif, afektif, dan psikomotorik, serta angket motivasi siswa. Hasil penelitian menunjukkan bahwa terdapat perbedaan hasil belajar dan motivasi belajar antara siswa yang menerapkan model pembelajaran STEM-PjBL dengan siswa yang menerapkan pembelajaran konvensional. Respon siswa terhadap penggunaan model dan media pembelajaran berbasis STEM-PjBL sebesar 41% sangat senang, 50% suka, dan 9% cukup baik.

Abstract

Redox and electrochemistry are materials that students consider difficult. One of the difficulties experienced by students is in balancing redox reactions using the oxidation number method. This condition is exacerbated by learning activities that must be carried out from home, resulting in low student motivation and learning outcomes. Therefore, innovative learning methods are needed but are still effective if applied online. One learning model that can be applied is STEM-PjBL, which is based on blended learning. The research aims to determine the differences in motivation and learning outcomes of students who are taught using the STEM-PjBL learning model based on blended learning and the lecture learning model. This research is quasi-experimental and uses a post-test-only control design research design. The research population was students of class XII Science at SMAN 5 Malang in the 2021/2022 academic year. The sample was class XII G and H, totaling 63 people by purposive sampling. The data collected include student learning outcomes, cognitive, affective, and psychomotor aspects, and student motivation questionnaires. The research results show differences in learning outcomes and motivation between students who apply the STEM-PjBL learning model and those who apply conventional learning. Student responses to using STEM-PjBL-based learning models and media were 41% very happy, 50% liked it, and 9% quite good.

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INTRODUCTION

The Covid-19 pandemic has tremendously impacted all aspects of life, including education. This difficult condition hurts the continuity of teaching and learning activities, especially in chemistry subjects. This is because chemistry subjects contain many abstract and complex concepts that make many students find it difficult to carry out learning chemistry from home. According to Haryani *et al.* (2014), students consider redox and electrochemical materials difficult (Haryani *et al.,* 2014). This statement is supported by research conducted by Rahayu *et al.* (2011), which states that students' understanding of redox and electrochemical materials is only 40% (Rahayu *et al.,* 2011). Based on research conducted by Anda et al. (2019), one of the difficulties faced by students in redox and electrochemical materials is that students have difficulty solving redox reactions using the oxidation state method and difficulties in solving redox reaction equations in an acid or alkaline environment (Anda *et al.*, 2019). This student difficulty is caused by teachers often delivering material orally (Amry & Yahmin, 2017), which impacts the low learning outcomes of redox and electrochemical materials (Dewi & Ahmadi, 2014).

To overcome learning difficulties in redox and electrochemical materials, a creative learning model that can be applied online is needed but is still effective in increasing student motivation and learning outcomes. One of the online learning models that can be used is Science, Technology, Engineering, and Mathematics (STEM). STEM is a multidisciplinary learning approach between science, technology, engineering, and mathematics. Problem-based learning, such as STEM, can create active and cohesive learning so students can integrate various abstract concepts from all aspects (Force, 2014). STEM learning naturally involves multiple skills, including reading, writing, mathematics, and building (Capraro & Slough, 2013). The implementation of STEM is in line with project-based learning (PjBL), which can improve cognitive learning outcomes (Baran & Maskan, 2010) and scientific process skills (Özer & Özkan, 2012), shape attitudes (Tseng *et al.*, 2013) and improve learning effectively (Cook *et al.*, 2012).

According to Tseng (2013), integrating STEM-PjBL can increase student motivation, create meaningful learning, help students solve problems, and support careers at the next level (Tseng *et al.*, 2013). By applying the STEM-PjBL learning model, students are expected to have high motivation to improve their learning outcomes, especially in redox and electrochemical materials.

The urgency of carrying out this research, in addition to overcoming students' learning difficulties in redox and electrochemical materials, is because, so far, the STEM-PjBL learning model has been implemented under normal conditions (face-to-face). There is still very little research on the implementation of the STEM-PjBL learning model that is carried out online; therefore, research data on the implementation of STEM-PjBL on redox and electrochemical materials is essential.

Have they been based on the STEM-PjBL and blended learning-based STEM-PjBL learning models? Blended learning /lectures, and (3) how students respond to implementing STEM-PjBL-based learning models and teaching materials when implemented online.

STEM-PjBL learning model. One of the learning approaches that can improve student competence is project-based learning. The project-based approach can provide active and effective student interaction by investigating, building, and developing an applicable and useful product. Project-based learning helps students develop a technological, social, and core curriculum (Sahin, 2013) and improve life skills (Arizona *et al.*, 2020). The life skills in question include personal, vaccine, academic, and social skills. Project-based learning is better than conventional learning to improve learning outcomes (Chasanah *et al.*, 2016).

This project-based learning (PjBL) can be integrated with STEM (Science, Technology, Engineering, and Mathematics). The STEM approach can provide meaningful learning by systematically integrating knowledge, concepts, and skills. The STEM-PjBL learning model aims to form individuals with scientific and technological literacy and concern and sensitivity to problems that arise in the environment and society.

According to (Adriyawati *et al.,* 2020), the STEM-PjBL learning process consists of five stages, each aiming to achieve a specific process.

Step 1. Reflection. The first stage aims to bring students into the context of the problem and provide inspiration for investigation. This phase is also intended to connect what is known and learned.

Step 2. Research. The second phase is a form of student research. There is much learning going on at this stage. The teacher provides science lessons by selecting literature or other methods to gather relevant sources of information. In this phase, the teacher guides students more often to determine whether the conceptual understanding relevant to the student's project has developed.

Step 3. Discovery. This stage generally involves bridging the research and information that is known in the preparation of the project. Students also begin to learn independently and determine what they have not mastered. Some STEM-PjBL models divide students into small groups to present solutions to a problem, collaborate, and build cooperation among group members. Meanwhile, another model uses this stage to develop students' abilities in building a habit of mind from the process of designing to designing.

Step 4. Application. The purpose of this stage is to test solutions in problem-solving. In some cases, students test products made from pre-defined conditions. In another model, at this stage, students learn a wider context outside of STEM or connect between STEM disciplines.
Step 5. Communication. The final stage of any project in making a product or solution is communicating between friends and the class. Presentation is an important stage in the learning process to develop communication and collaboration skills and the ability to receive and apply constructive feedback. Assessment is often done based on the completion of this phase.

STEM-PjBL-basd learning. Model The blended learning-based STEM-PjBL learning model integrates the interactive STEM-PjBL learning model with the unique flexibility of blended learning. Blended learning is an educational program that allows students to learn online with freedom of time, place, sequence, and pace of learning (Staker & Horn, 2017). The advantages of blended learning, according to Husamah (2014), include 1) advantages that online and conventional learning can complement each other in 1 learning, 2) learning activities become effective and efficient, and 3) minimal costs but optimal results (Husamah, 2014).

The use of STEM-PjBL based on blended learning is utilizing gadgets that students have by providing STEM-PjBL-based teaching materials in the form of a flipbook developed by Widarti *et al.* (2020) to build student understanding through various illustrations and practice questions given as well as project assignments carried out in groups at the school (Widarti *et al.*, 2020). House. In this research, blended learning is fully implemented online, where the synchronous activities are meetings in *Google Classroom*, and the asynchronous activities are learning activities other than meetings, such as discussions through chat rooms, working on assignments and projects, and collecting assignments.

Learning outcomes learning. Outcomes are benchmarks teachers use to determine the improvement in students' understanding and skills after participating in the learning process (Ricardo & Meilani, 2017). The teacher has the task of measuring the level of awareness and skills and how the behavior changes of the students who have been guided following the competencies achieved. These learning outcomes are used as teacher evaluations to rethink the learning system that will be applied next (Setiawan, 2020). According to Bloom's theory, there are three domains of learning outcomes, namely (1) cognitive, which shows an assessment of knowledge; (2) affective, which shows the views and attitudes of students; and (3) psychomotor, which shows an assessment of student skills (Arikunto, 2009). Further information regarding learning outcomes from Bloom's theory is as follows.

Cognitive. Cognitive learning outcomes are student learning outcomes related to thinking skills obtained from learning activities. It is carried out using written tests, oral tests, or the like to measure student success in the cognitive domain. Based on Bloom's taxonomy, the cognitive domain is divided into several categories (Arikunto, 2009) as follows: (a) Knowing/C1, (2) Understanding/C2, (3) Application/C3, (4) Analysis/C4, (5) Synthesis/C5, and (6) Affective Evaluation/C6

Affective. Affective learning outcomes are learning outcomes related to changes in behavior, attitudes, or responses possessed by students after having a cognitive understanding. A Likert scale of 1-5 was used to measure student success in the affective domain. Aspects assessed in the affective domain include acceptance, welcome, appreciation, internalization, and characterization.

Psychomotor. The psychomotor aspect is seen from the appearance or skills of students shown in the learning process. Assessment of psychomotor aspects using performance, presentation, and product assessments.

From the statement above, it can be concluded that learning outcomes are changes in behavior resulting from the learning process that involves cognitive, affective, and psychomotor abilities.

Learning motivation. The origin of the word motivation is a motive, which means the condition in an individual that encourages them to carry out certain activities, whether consciously or not, to achieve a certain goal (Winarni *et al.*, 2016). Learning motivation can also be interpreted as a driving force to carry out learning activities that can come from inside and outside the individual to foster a spirit of learning (Monika & Adman, 2017). Learning motivation is a requirement for a student to want to learn and is important in providing enthusiasm for learning. Learning motivation is a driving force to achieve good results and contains efforts to achieve these learning goals (Puspitasari, 2013). So, it can be said that learning motivation determines the intensity of learning efforts, which impacts increasing learning outcomes (Palupi, 2014).

METHOD

This research is a continuation of research conducted by (Rokhim *et al.*, 2020) regarding the development of flipbook STEM-PjBL-based instruments developed by (Rokhim *et al.,* 2020) used in this study, including flipbooks and learning outcomes assessment instruments (cognitive, affective, and psychomotor).

The research design used was a quasi-experimental design with a post-test-only control design so that after being treated using a learning model, a post-test or daily test was carried out after a series of learning processes had been completed.

The research population is class XII students of SMAN 5 Malang in the academic year 2021/2022. The samples used in this study were students of class XII G5 as the control class, which amounted to 32 people, and students of class XII H5 as the experimental class, which amounted to 31 people. The experimental class is a class that is taught using the STEM-PjBL model based on blended learning, while the control class is a class that applies a conventional learning model. Data collection was carried out for eight meetings (2x30 minutes). The independent variable in this study is the STEM-PjBL learning model. The dependent variable is student learning outcomes on redox and electrochemical materials. The control variables were redox and electrochemical materials, teachers, and the research time.

The instruments used in the study consisted of treatment and measurement instruments. The treatment instrument consisted of a syllabus, lesson plans for the experimental and control classes, LKPD for the control class, and STEM-PjBL-based teaching materials. The syllabus for this activity is the same and has been adapted to the learning model applied to each class. The syllabus can be seen in Appendix 1. The percentage of syllabus validation reaches 91.85%. The experimental and control class RPP can be seen in Appendix 4 and Appendix 7. The rate of experimental RPP validation reaches 94.3%, while the control class percentage reaches 90.75%. LKPD can be seen in Appendix 9, with a validation percentage of 94%. STEM-PjBL-based teaching materials on redox and electrochemical materials developed by (Rokhim *et al.,* 2020) were applied to the experimental class. The teaching materials have passed the validation test and readability test. The results of the validity of teaching materials reached 92.71%, while the results of the readability test reached 98.31%.

The measurement instrument consisted of an assessment instrument for developmental learning outcomes from (Rokhim *et al.*, 2020), a student learning motivation questionnaire, a student response questionnaire to STEM-PjBL-based teaching models and materials, and observation sheets. The cognitive learning outcome assessment instrument consists of 20 multiple-choice questions, five true-false questions, and five causal questions for outcomes, and for affective and psychomotor learning outcomes, observation sheets are used.

There are three observers to observe the learning process. The observers comprised two students from the State University of Malang and one chemistry teacher at SMAN 5 Malang. Malang State University students Augusto Daniel Setiaji and Ajeng Kusumawati acted as observers. The chemistry teacher who worked as an observer was Mrs. Desak Putu Agung Herti Santi, S.Si., M.Pd.

In this study, two kinds of data were taken, namely (1) daily test scores to determine students' abilities and (2) questionnaires to determine students' learning motivation for redox and electrochemical materials, as well as the application of media and learning models based on STEM-PjBL.

The steps in data collection are as follows: (1) administering research permits, (2) collecting data on the initial abilities of students in both classes, (3) determining research samples, (3) giving treatment to the experimental and control classes, (4) implementing tests to determine student learning outcomes at the end of the meeting, (5) distributing questionnaires.

The data analysis techniques carried out include 1) Cognitive Ability Analysis, 2) Descriptive Analysis of Affective Ability, 3) Descriptive Analysis of Psychomotor Ability, 4) Student Learning Motivation, and 5) Student Responses to Learning and Teaching Materials Based on STEM-PjBL.

RESULT AND DISCUSSION

Result

Initial ability students

Initial abilities were obtained from secondary data, namely daily test scores on the previous material (solution colligative system). Based on the analysis prerequisite test in Appendix 20, the normality test for the control and experimental classes has a sig = 0.2. The homogeneity test resulted in a Sig. = 0.689. This shows that the data has a normal and homogeneous distribution. Then, the Independent Sample T-Test resulted in Sig. (2-tailed) = 0.056. This indicates that the initial ability of the two classes is not significantly different, so it is suitable for use as a research sample.

Student learning outcomes

Student learning outcomes are grouped into cognitive, affective, and psychomotor learning outcomes. The following are the results of the research.

Cognitive. Cognitive learning outcomes data obtained from students' scores after working on evaluating redox and electrochemical material are briefly presented in Table 1.

Table 1. Cognitive learning outcomes data

Range of values	Experiment	Class control class
Average score	80.07	76.16
Number of students	31	32
Highest score	98	97
Lowest score	57	30
% Completeness	88%	72%

The first step in the analysis is to test for normality and homogeneity. In the normality test, the value of Sig. control class is 0.07, while the value of Sig. experimental class is 0.2. In the homogeneity test, the value of Sig. is 0.370. From the normality and homogeneity test, it can be concluded that the data distribution is normal and homogeneous-based STEM-PjBL learning model blended learning with the conventional independent sample t-test. The hypothesis proposed is

H_0: There is no significant difference in learning outcomes between students taught the STEM-PjBL learning model and conventional methods.

H_1: There is a significant difference in learning outcomes between students taught the STEM-PjBL learning model and those taught conventional methods.

From the independent sample t-test, the Sig. Value was obtained. (2-tailed) of 0.02, so it can be concluded that there is a significant difference in learning outcomes between students taught the STEM-PjBL learning model and conventional methods.

Affective. Affective learning outcomes data are data taken through observations by observers and researchers who were observed at each meeting. These affective aspects include attendance in *Google Meet*, attention/seriousness, enthusiasm of students, activeness in asking questions, answering questions, and expressing opinions, and accuracy in collecting assignments. The data on affective learning outcomes are briefly described in Table 2.

Based on the results obtained from the analysis, the percentage of students' affective abilities taught using the STEM-PjBL and conventional learning models are presented in Figure 1.

Psychomotor. Data on students' psychomotor abilities taught using the STEM-PjBL and conventional models are presented in Table 3.

Table 2. Affective learning outcomes data

Range of values	Experiment	Class control class
Average	86.87	84.60
Number of students	32	32
Highest score	100	100
Lowest score	75	75

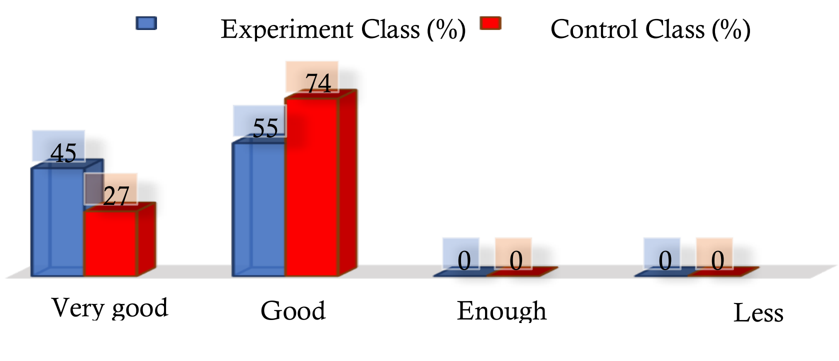

Figure 1. Students affective score

Table 3. Psychomotor learning outcomes data

Range of values	Experiment	Class control class
Average	87.03	81.26
Total Students	32	32
Highest scores	98	92
Lowest scores	75	73

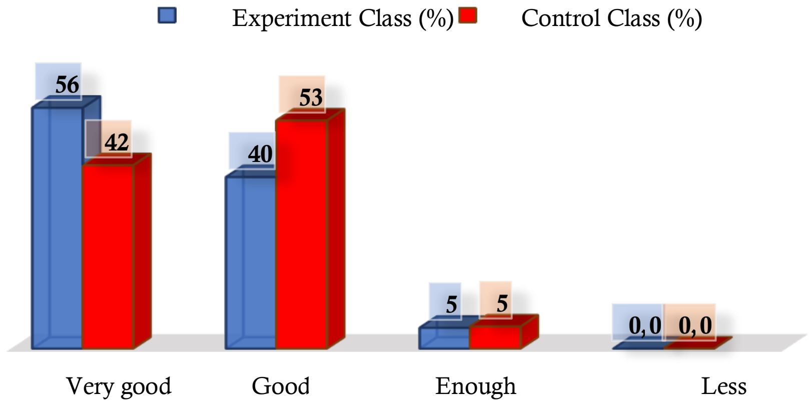

Figure 2. Students' psychomotor score

The percentage of students whose psychomotor abilities were taught using the STEM-PjBL and conventional learning models can be seen in Figure 2.

Learning motivation. In order to determine students' learning motivation during learning activities with redox and electrochemical materials in the experimental and control classes, a student learning motivation questionnaire was used.

Student learning motivation questionnaires were grouped into three factors, namely (1) Attention, (2) Confidence, and (3) Satisfaction. The three factors were then further divided into 16 descriptors and developed into 31 statements, with four answer criteria for each question, namely strongly agree (SS) = 5, agree (S) = 4, disagree (KS) = 3, disagree (TS) = 2, and strongly disagree (STS) = 1.

The comparison of learning motivation between the experimental and control classes in terms of these three factors is as follows:

Attention (Attention to learning). The total score of the students' results of filling out the questionnaire on each descriptor in points attention can be seen in Table 4. Based on Table 4, the comparison of learning motivation between experimental and control classes in terms of attention can be briefly represented in Figure 3.

Table 4. Total score influence of attention factors on learning motivation

Descriptors	Total score	
	Experiment class	Control class
Attendance in class	259	245
Attention to assignments	133	117
Timeliness of completing tasks	270	261

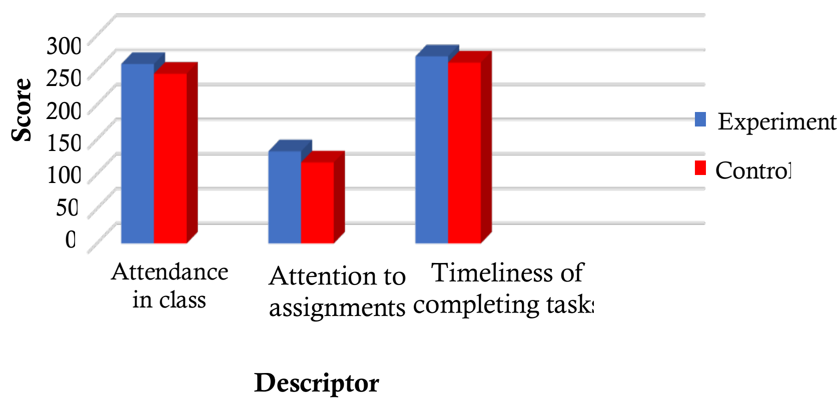

Figure 3. Comparison of the number of learning motivation scores influenced by attention

Confidence. The total score of the results of students filling out questionnaires on each descriptor in confidence can be seen in Table 5. Based on Table 5, a comparison of learning motivation between classes' Experiments and controls in terms of attention can be briefly represented in Figure 4.

Satisfaction. The total satisfaction score of the students who filled out the questionnaire on each descriptor can be seen in Table 6. Based on Table 6, a comparison of learning motivation between the experimental and control classes in attention can be briefly represented in Figure 5.

Table 5. Total scores of the influence of confidence factors

Descriptor	Total score	
	Experiment class	Control class
Confidence in success	424	401
Confidence in the subject matter	270	261
Confidence in understanding the lesson	363	345
Aspirations	133	117
Finding another reference	393	371
Confidence	270	261

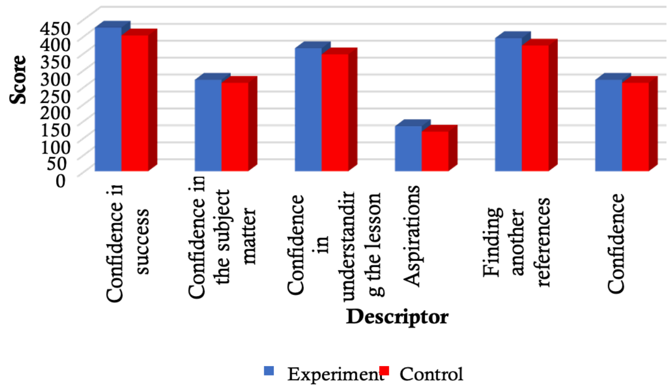

Figure 4. Comparison of the number of learning motivation scores influenced by confidence

Table 6. Total score of the influence of satisfaction factors on learning motivation

Descriptors	Total	
	Experiments class	Control class
Satisfaction with learning outcomes	130	118
Feeling happy with the help	123	123
Willingness to help peers	128	128
Desire for achievement	476	460
Enjoyment in learning	357	330
Satisfied during the class	122	114
Satisfied during the test	124	109

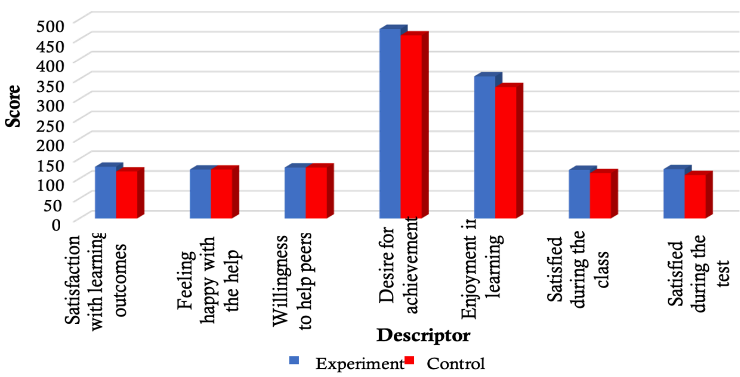

Figure 5. Comparison of the number of learning motivation scores influenced by the satisfaction

Table 7. Student responses to the STEM-PjBL learning model

Information	Number of students	Percentage (%)
Very liked	13	40.6
Liked	16	50.0
Fairly liked	3	9.4
Less unliked	0	0
Very unliked	0	0

Then, an analysis was carried out using SPSS to determine whether there were differences in students' learning motivation. Based on the prerequisite test for analysis, the normality test of Sig. control class is 0.2, while the value of Sig. experimental class is 0.192. In the homogeneity test, the value of Sig. is 0.592. From the normality and homogeneity test, it can be concluded that the data distribution is normal and homogeneous STEM-PjBL learning model blended learning with the conventional independent sample t-test. The hypothesis proposed is:

H_0: There is no significant difference in learning motivation between students taught the STEM-PjBL learning model and conventional methods.

H_1: There is a significant difference in learning motivation between students taught the STEM-PjBL learning model and conventional methods.

From the independent sample t-test, the sig value was obtained. (2-tailed) of 0.00 so that it can be concluded that there is a significant difference in learning motivation between students who are taught the STEM-PjBL learning model with conventional methods.

Student responses to STEM-PjBL-based learning and teaching materials

A questionnaire instrument was used to determine student responses in the experimental class to learning using the STEM-PjBL model. Data on student responses to the STEM-PjBL learning model can be seen in Table 7.

Discussion

Cognitive

Based on the independent sample t-test, it has been proven that there is a significant difference in student learning outcomes for those taught the STEM-PjBL learning model based on blended learning and conventional learning. This is because, in the learning process, students construct their knowledge. Coupled with the help of STEM-PjBL-based teaching materials and the project assignments they use, students' understanding of redox and electrochemistry is strengthened. Students not only know and memorize the material but also understand how and what processes occur in redox and electrochemical reactions, such as where electrons move, why in one series a redox reaction can run but in another, it does not, and how to solve problems when the reaction occurs redox not working. All the understandings formed by these students directly impact the value of their learning outcomes. Students become more confident and better when working on post-test questions.

Affective

The results of the affective data analysis in Figure 1 show that the affective abilities of students taught using the STEM-PjBL model based on blended learning are better than those taught using the conventional model. This is because, in the previous material, learning was carried out with a conventional model, namely lectures, so students felt bored. Therefore, when receiving learning with the STEM-PjBL model based on blended learning, students feel more excited because they get a new learning atmosphere. The affective ability of students turned out to have a linear influence on learning outcomes. This statement is supported by (Widyantari *et al.*, 2019), which states a positive relationship between affective abilities and student learning outcomes. As seen in the experimental class, which has a relatively high affective value, it is also accompanied by higher learning outcomes than students in the control class. Thus, it can be said that the application of the STEM-PjBL learning model has a positive influence on student attitudes.

Psychomotor

Based on the analysis shown in Figure 2, the psychomotor abilities of students taught using the STEM-PjBL model based on blended learning are better than those taught using the conventional model. This happens because students actively participate in proving concepts in assembling voltaic cells, not just observing via video the arrangement of voltaic cells and how they work.

The discussion of the cognitive, affective, and psychomotor aspects above proves that the STEM-PjBL learning model can improve student learning outcomes on redox and electrochemical materials. The results of this experiment are in line with research conducted by Saputra & Sujarwanta (2021) that STEM-PjBL learning can improve students' competence (Saputra & Sujarwanta, 2021) and Sastrika (2013) shows that project learning can improve concept mastery (Sastrika *et al.*, 2013). This finding is reinforced by the results of Furi's research (2018) that the STEM-integrated PjBL learning model can significantly improve concept mastery (Furi *et al.*, 2018), in addition to the results of research by Saregar (2016) which states that a student-oriented approach is generally more effective in increasing students' interest and mastery of concepts (Saregar, 2016), Noor (2017) also revealed that online project-based learning is effective in achieving student learning mastery (Noor *et al.,* 2017).

The STEM-PjBL learning model, through its stages, also provides opportunities so that students are always active and continue to build their knowledge, individually and in groups so that there are always changes to concepts into detailed, complete, and following the correct concepts. In addition, the STEM-PjBL learning model can create regularity in the learning process to make students better understand the material being studied, develop thinking skills, and ultimately increase learning outcomes.

Student learning motivation learning

Motivation has an important role in achieving the goals or learning outcomes set. According to Emda (2018), learning motivation will let students know the direction of their learning (Emda, 2018). The following is a comparison of the results of student questionnaires regarding the learning motivation of the experimental and control classes, which are influenced by attention, confidence, and satisfaction, presented in Figure 6.

Based on Figure 6, it can be seen that the control class in the "motivated" category has a percentage higher than the experimental class. The cause of this phenomenon is that students are more accustomed to using worksheets than flipbooks. However, using conventional learning models decreases students' learning motivation, reflected in the "less motivated" category, where the percentage of the control class is higher than the experimental class. In the "highly motivated" category, students in the experimental class have higher learning motivation than the control class. This happens because students who are taught using the STEM-PjBL model tend to be more active, so students are more motivated during learning activities. Students feel more excited because previously, the teacher used a conventional model, namely lectures, so the class atmosphere tended to be boring. Student learning motivation also has a relationship with learning outcomes. In line with what was conveyed by Budi Ariawan (2019) and Yudanti (2021), there is a positive and significant relationship between motivation and learning outcomes (Budiariawan, 2019; Yudanti & Premono, 2021). It can be seen in Table 6 that the average score of students in the experimental class is higher than the average score of students in the control class. Thus, it can be said that applying the STEM-PjBL learning method positively influences students' motivation to learn.

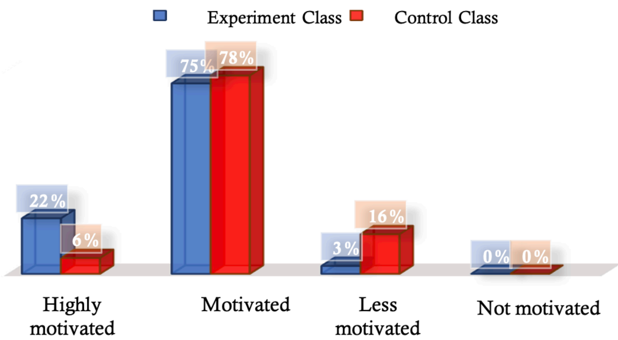

Figure 6. Students learning motivation

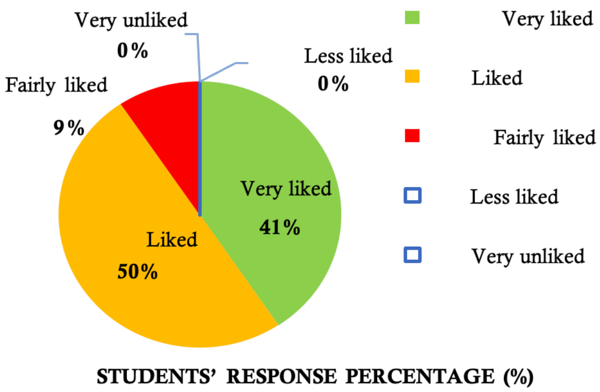

Figure 7. Percentage of student responses to the STEM-PjBL learning model

Student responses to STEM-PjBL-based learning and teaching materials

In summary, the data on student responses to using STEM-PjBL-based learning models and teaching materials are presented in Figure 7.

Students like applying STEM-PjBL-based learning models and teaching materials to redox and electrochemical materials, as shown in Figure 7. This is because STEM-PjBL-based learning contains interactive activities that reduce boredom in learning. Students are happy and interested because the project assignments make them learn in a new, fun atmosphere, in the sense that they do not just sit and listen to the teacher lecturing while delivering the material. In addition, STEM-PjBL-based teaching materials also contain a variety of videos and animations covering the macroscopic, submicroscopic, and symbolic domains, including several concepts related to their application in everyday life, so that they are effective when carried out in learning activities. The material is also coherent, which makes it easier for students to understand the concept.

CONCLUSION

Based on the STEM-PjBL learning model, they have blended learning and conventional learning. This is evidenced by Sig (2-tailed), which has a value of 0.02. The STEM-PjBL learning model was blended learning also better than students who were taught using the conventional model. This is evidenced by the percentage of students' affective abilities taught using the STEM-PjBL learning model of 45% very good and 55% good. The affective ability of students taught using conventional learning models is 27% very good and 74% good.-based STEM-PjBL learning model blended learning was 56% very good, 40% good, and 5% sufficient. The psychomotor abilities of students taught using conventional learning models are 42% very good, 40% good, and 5% enough.

There is a significant difference in learning motivation between students who are taught using the STEM-PjBL learning model based on blended learning and those who are conventional. In the experimental class, the percentage of student motivation was 22% very good, 75% good, and 3% quiet. Meanwhile, in the control class, the percentage of students' motivation was 6% very good, 78% good, and 16% quiet.

Students like applying STEM-PjBL-based learning models and teaching materials that are carried out online. This statement is based on the results of student questionnaires, which produced a percentage of 41% very good, 50% good, and 9% quite good.

REFERENCES

Adriyawati, Utomo, E., Rahmawati, Y., & Mardiah, A. 2020. Steam-Project-Based Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning. *Universal Journal of Educational Research*, *8*(5): 1863–1873

Amry, U.R.S., & Yahmin. 2017. Analisis Miskonsepsi Asam Basa pada Pembelajaran konvensional dan Dual Situated Learning Model (DSLM). *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *2*(3): 385–391

Anda, M., Suryani, E., & Nursyamsi, D. 2019. Soil Mineralogy and Dynamic Pedogenic Processes in Response to Redox Cycles Due to Rice and Sweet Potato Rotation. *Soil Research*, *58*(2): 174–188

Arikunto, S. 2009. *Dasar-Dasar Evaluasi Pendidikan*. Bumi Aksara

Arizona, K., Abidin, Z., & Rumansyah, R. 2020. Pembelajaran Online Berbasis Proyek Salah Satu Solusi Kegiatan Belajar Mengajar di Tengah Pandemi Covid-19. *Jurnal Ilmiah Profesi Pendidikan*, *5*(1): 64–70

Baran, M., & Maskan, A. 2010. The Effect of Project-Based Learning on Pre-Service Physics Teachers Electrostatic Achievements. *Cypriot Journal of Educational Sciences*, *5*(4): 243–257

Budiariawan, I. P. 2019. Hubungan Motivasi Belajar dengan Hasil Belajar pada Mata Pelajaran Kimia. *Jurnal Pendidikan Kimia Indonesia*, *3*(2): 103–111

Capraro, R.M., & Slough, S.W. 2013. Why PBL? Why STEM? Why Now? An Introduction to STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach. In *STEM project-based learning* (pp. 1–5). Brill

Chasanah, A.R.U., Khoiri, N., & Nuroso, H. 2016. Efektivitas Model ProjectBased Learning terhadap Keterampilan Proses Sains dan Kemampuan Berpikir Kreatif Siswa pada Pokok Bahasan Kalor Kelas X SMAN 1 Wonosegoro Tahun Pelajaran 2014/2015. *Jurnal Penelitian Pembelajaran Fisika*, *7*(1): 19–24

Cook, K., Buck, G., & Rogers, M.P. 2012. Preparing Biology Teachers to Teach Evolution in a Project-Based Approach. *Science Educator*, *21*(2)

Dewi, C.A., & Ahmadi, A. 2014. Pengaruh Pembelajaran Savi Berbasis Media Simulasi Interaktif terhadap Keterampilan Berpikir Kritis Mahasiswa pada Materi Elektrokimia. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *2*(1): 8–11

Emda, A. 2018. Kedudukan Motivasi Belajar Siswa dalam Pembelajaran. *Lantanida Journal*, *5*(2): 172–182

Force, S.T. 2014. Innovate: A Blueprint for Science, Technology, Engineering, and Mathematics in California Public Education. *Dublin, CA: Californians Dedicated to Education Foundation*

Furi, L.M.I., Handayani, S., & Maharani, S. 2018. Eksperimen Model Pembelajaran Project-Based Learning dan Project-Based Learning Terintegrasi STEM untuk Mengingkatkan Hasil Belajar dan Kreativitas Siswa pada Kompetensi Dasar Teknologi Pengolahan Susu. *Jurnal Penelitian Pendidikan*, *35*(1): 49–60

Haryani, S., Prasetya, A.T., & Permanasari, A. 2014. Developing Metacognition of Teacher Candidates by Implementing Problem-Based Learning within the Area of Analytical Chemistry. *International. Journal of Science and Research (IJSR)*, *3*(6): 1223–1229

Husamah, H. 2014. Pembelajaran Nauran (Blended Learning). *Research Report*

Monika, M., & Adman, A. 2017. Peran Efikasi Diri dan Motivasi Belajar Dalam Meningkatkan Hasil Belajar Siswa Sekolah Menengah Kejuruan. *Jurnal Pendidikan Manajemen Perkantoran*, *2*(2): 109

Noor, M.E., Hardyanto, W., & Wibawanto, H. 2017. Penggunaan E-Learning dalam Pembelajaran Berbasis Proyek di SMA Negeri 1 Jepara. *Innovative Journal of Curriculum and Educational Technology*, *6*(1): 17–26

Özer, D.Z., & Özkan, M. 2012. Proje Tabanlı Öğretimin fen Bilgisi Öğretmen Adaylarının Bilimsel Süreç Becerileri Üzerine Etkisi. *Journal of Turkish Science Education*, *9*(3): 119–130

Palupi, R. 2014. Hubungan antara Motivasi Belajar dan Persepsi Siswa terhadap Kinerja Guru dalam Mengelola Kegiatan Belajar dengan Hasil Belajar IPA Siswa Kelas VIII di SMPN N 1 Pacitan. *Jurnal Teknologi Pendidikan Dan Pembelajaran*, *2*(2)

Puspitasari, A. 2013. Self-Regulated Learning Ditinjau dari Goal Orientation. *Educational Psychology Journal*, *2*(1)

Rahayu, I.P., Yulianingsih, U., Septiani, D., & Wijaya, A.A. 2011. Inovasi Pembelajaran Berbasis Masalah Berbantuan Media Transvisi untuk Meningkatkan Keterampilan Proses Sains. *Pekan Ilmiah Mahasiswa Nasional Program Kreativitas Mahasiswa-Penelitian 2013*

Ricardo, R., & Meilani, R.I. 2017. Impak Minat dan Motivasi Belajar terhadap Hasil Belajar Siswa. *Jurnal Pendidikan Manajemen Perkantoran*, *1*(1): 79–92

Rokhim, D.A., Widarti, H.R., & Fajaroh, F. 2020. Pengembangan Bahan Belajar Flipbook pada Materi Redoks dan Elektrokimia Berbasis Pendekatan STEM-PjBL Berbantuan Video Pembelajaran. *Kwangsan: Jurnal Teknologi Pendidikan*, *8*(2): 234–250

Sahin, A. 2013. STEM Project-Based Learning: Specialized Form of Inquiry-Based Learning. STEM Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach, 59–64

Saputra, B., & Sujarwanta, A. 2021. Transformasi Pembelajaran Berbasis Proyek Science, Technology, Engineering and Mathematics di Masa Pandemi Covid-19. *Biolova*, *2*(1): 1–8

Saregar, A. 2016. Pembelajaran Pengantar Fisika Kuantum dengan Memanfaatkan Media Phet Simulation dan LKM melalui Pendekatan Saintifik: Dampak pada Minat dan Penguasaan Konsep Mahasiswa. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *5*(1): 53–60

Sastrika, I.A.K., Sadia, W., & Muderawan, I.W. 2013. Pengaruh Model Pembelajaran Berbasis Proyek terhadap Pemahaman Konsep Kimia dan Keterampilan Berpikir Kritis. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, *3*(2)

Setiawan, A.R. 2020. Motivasi dan Hasil Belajar dalam Pembelajaran Adaptif Fisika menggunakan Naḍom Mabādī ʻAsyroh. *WaPFi (Wahana Pendidikan Fisika)*, *5*(2): 132–146

Staker, H., & Horn, M.B. 2017. The Blended Workbook: Learning to Design The Schools of Our Future. John Wiley & Sons

Tseng, K.H., Chang, C.C., Lou, S.J., & Chen, W.P. 2013. Attitudes Towards Science, Technology, Engineering and Mathematics (STEM) in a Project-Based Learning (PjBL) Environment. *International Journal of Technology and Design Education*, *23*: 87–102

Widarti, H.R., Rokhim, D.A., & Syafruddin, A.B. 2020. The Development of Electrolysis Cell Teaching Material Based on STEM-PjBL Approach Assisted by Learning Video: A Need Analysis. *Jurnal Pendidikan IPA Indonesia*, *9*(3): 309–318

Widyantari, N.K.S., Suardana, I.N., & Devi, N.L.P.L. 2019. Pengaruh Strategi Belajar Kognitif, Metakognitif dan Sosial Afektif terhadap Hasil Belajar IPA. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *2*(2): 151–160

Winarni, M., Anjariah, S., & Romas, M.Z. 2016. Motivasi Belajar Ditinjau dari Dukungan Sosial Orangtua pada Siswa SMA. *Jurnal Psikologi*, *2*(1)

Yudanti, N.A., & Premono, S. 2021. Hubungan antara Minat dan Motivasi terhadap Hasil Belajar pada Pembelajaran Block System Proses Industri Kimia. *Journal of Tropical Chemistry Research and Education*, *3*(1): 10–17.