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Application of STEAM in PBL to Improve Creativity and Science Learning Outcomes: Case Study of Learning at SD Inpres Tanamodindi Palu

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Abstract: The purpose of this study is to explore the implementation of Science, Technology, Engineering, Arts, and Mathematics (STEAM) within a problem-based learning (PBL) approach to enhance students' creativity and learning outcomes in science subjects at SD Inpres Tanamodindi. The research was conducted in Grade V of SD Inpres 1 Tanamodindi Palu, where students exhibit diverse academic abilities. Following the research design proposed by Kemmis and McTaggart (2013) and Zhong, Y. (2024), the study was carried out in two cycles. Data collection methods included observations, interviews, field notes, and learning outcome assessments. The findings reveal that integrating the STEAM approach into the PBL model at SD Inpres Tanamodindi led to an improvement in learning outcomes, rising from 64.65 in the first cycle to 71.77 in the second cycle. Additionally, students' creativity in solving science-related problems improved, progressing from the "sufficient" category in cycle 1 to the "very good" category in cycle 2.

Keywords: Creativity; Learning outcomes; PBL; Science; STEAM

Introduction

In Regulation of the Minister of Education, Culture, Research, and Technology Number 12 of 2024, as well as Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 57 of 2014 on the 2013 Curriculum, Article 11 Paragraph 1 emphasizes the importance of an integrated thematic approach in elementary school/madrasah education. This approach allows teachers to integrate various learning content based on the theme being taught. However, in practice, many teachers still tend to apply a partial teaching method, where they teach one subject matter first before moving on to another, rather than delivering them simultaneously. As a result, more time is consumed, making it difficult to achieve the learning objectives outlined in the Lesson Plan (RPP) effectively.

The results of interviews with teachers at SD Inpres Tanamodindi indicate that they have not yet fully implemented learning that integrates various subjects into a single theme. This is due to their limited understanding of the instructional approach that allows for the integration of multiple learning materials. As a result, the learning process takes longer than planned, causing students to become easily bored, lose focus, and have less opportunity to develop their creativity.

Previous research by Roshayanti et al. (2022) revealed that many teachers have not yet fully

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understood the concept or methods of STEAM-based learning, which integrates multiple disciplines. As a result, learning objectives are not optimally achieved. James (2022) also emphasized the need for teacher collaboration to enhance STEAM education and support their professional development.

Additionally, teachers face difficulties in designing evaluation instruments that align with learning objectives. When well-structured evaluations are developed, teachers can accurately assess students' learning achievements. Kasman et al. (2022) stated that evaluation instruments should be systematically structured in line with learning objectives to ensure their achievement.

Furthermore, research by Muslim et al. (2023) found that teachers tend to rely more on summative assessment rather than formative assessment in science education. This practice affects the attainment of learning objectives, as students often fail to meet the Minimum Competency Criteria (MCC) set by the school.

Based on these issues, this study aims to encourage teachers to collaborate in learning by implementing the Problem-Based Learning (PBL) model with a STEAM-based approach in science subjects. The application of this approach is expected to enhance teachers' understanding of integrating various learning content and help students become more focused, active, and creative in the learning process. Alamha et al. (2025) stated that the use of PBL (Problem-Based Learning) can improve students' critical thinking skills and learning outcomes. Sadiah et al. (2025) stated that the problem-based learning model influences students' physics problem-solving skills. Priyatno et al. (2025) stated that the use of the Problem Based Learning model in science and social studies learning can improve student learning outcomes. Sudarti et al. (2024) stated that STEAM learning can enhance children's creative thinking skills. (Wahyudi et al., 2024) found in their research that project-based learning integrated with STEAM can improve students' creative and collaborative thinking skills as well as their social studies learning outcomes. Sudarti et al. (2024) demonstrated in their research that the STEAM approach is effective in fostering creativity in early childhood education.

Amir et al. (2021) revealed that STEAM in science learning can improve students' learning outcomes and engagement. Additionally, this model encourages individual communication within groups, as stated by Sudarti et al. (2023), and enhances literacy and numeracy skills in digital learning, as highlighted by Hidayanthi et al. (2024). Furthermore, Brecl et al. (2024) emphasized that the implementation of STEAM with gamification elements can bridge gaps in students' understanding and participation.

Thus, this study aims to implement the PBL model with a STEAM approach in science learning for fifth-grade students at SD Inpres Tanamodindi. Through the application of this model, it is expected that teachers can enhance their understanding of integrating various subject materials and create a more effective, engaging, and outcome-oriented learning experience, thereby improving students' academic achievement beyond the predetermined MCC.

Method

This study is a Classroom Action Research (CAR) conducted at SD Inpres 1 Tanamodindi, Palu, Indonesia. The research was carried out in Grade V, consisting of 26 students with heterogeneous academic abilities. The study was designed in a cyclical manner, referring to Kemmis et al. (2014) and Zhong (2024), encompassing three stages: (1) Planning, (2) Implementation and Observation, and (3) Reflection.

Data collection techniques included learning outcomes, field notes, interviews, and observation methods. The success of the intervention was measured based on the increase in classical mastery from one cycle to the next after the implementation of the Problem-Based Learning (PBL) model with a STEAM approach. The classical mastery threshold at this school was set at 60%.

Result and Discussion

The following section describes the learning results that students at SD Inpres Tanamodindi Palu achieved after applying the STEAM Approach in the Problem-Based Learning Model in material science during each learning cycle.

Science Learning Outcomes

The application of STEAM (Science, Technology, Engineering, Arts and Mathematics) in PBL at SD Inpres Tanamodindi Palu shows learning outcomes that exceed the standards set by the school, namely MCC = 60. The increase in the average student learning outcomes in cycle 1 and cycle 2 compared to the KKM is depicted in Table 1-4 as follows:

Cycle 1

Data on student learning outcomes from 23 students who have participated in learning with the PBL model using the STEAM approach in cycle 1 are described in Table 1.

Based on Table 1, it shows that 56.52% of learning outcomes meet the Minimum Completion Criteria (MCC) = 60. The percentage above provides an

illustration that student learning outcomes in cycle 1 science materials have not met the 60% threshold which exceeds a score of 60.

Table 1. Data on Student Learning Outcomes in Cycle 1

Cycle 1 learning outcomes									
50	50	50	50	54	57	57	59	59	59
62	65	67	67	69	71	71	75	75	75
77	82	86							

This is in line with the research results of Istianah (2023) which stated that based on the results of observations in STEM learning in solving problems related to the environment, the average score was 54.8% or in the "sufficient" category. The average learning outcomes in cycle 1 are presented in Table 2.

Table 2. Descriptive Statistics for Cycle 1

	N	Min	Max	Mean	Std. Deviation	Variance
Cycle 1	23	50.00	86.00	64.6522	10.73062	115.146

Based on the results of data analysis, it was found that range = 36 and the average student learning outcomes in cycle I was 64.65, which exceeded the MRC value. However, there are still quite a lot of students who get scores below the average.

Cycle 2

Data on student learning outcomes from 25 students who have participated in learning with the PBL model using the STEAM approach in cycle 2 are described in Table 3. Based on the analysis results in Table 3, it was obtained that 76.00% met the Minimum Completion Criteria (KKM) set by the school, namely KKM = 60. These results indicate an increase in the number of students who completed compared to cycle 1 after the STEAM learning approach was implemented in PBL. The average learning outcomes in cycle 2 are presented in Table 4.

Table 4 shows that the results of data analysis in cycle 2 after implementing learning using the STEAM approach in the PBL model with several improvements from cycle 1 obtained an average score of 71.77 from 25 students. Based on the results of the analysis presented in Tables 2 and 4, it shows that there has been an increase in the average value, namely from 64.65 in cycle 1 to 71.77 in cycle 2.

Table 3. Data on Student Learning Outcomes in Cycle 2

Cycle 2 learning outcomes									
50	50	54	54	54	57	61	63	63	65
69	69	71	75	78	79	79	79	84	84
86	88	90	90	90					

Table 4. Descriptive Statistics Cycles 2

	N	Range	Min	Max	Mean	Std. Dev	Variance
Cycle 2	25	40.00	50.00	90.00	71.77	13.50943	182.505

Participation and Involvement in Problem Solving

Students' enthusiasm in solving science problems has increased significantly. This can be seen from the results of observations of student activities when implementing the STEAM method combined with problem-based learning (PBL).

This increase is supported by data on learning outcomes for cycle 1 and cycle 2 presented in Table 5 and Table 6. Table 5 data shows that in cycle 1, students' enthusiasm for participating in learning was still in the "sufficient" category; however, after improvements and refinements were made in the implementation of learning during cycle 2, enthusiasm increased to the "good" category. This increase indicates that the STEAM approach, which emphasizes the integration of various disciplines or learning content, successfully motivated students to be more active and engaged in the problem-solving process. These findings align with the research results of Mater et al. (2023), which state that STEAM-based learning activities influence the motivation, mental state, and learning of 9th-grade students. Furthermore, Ardi et al. (2025) revealed that PBL-based e-LKPD with a STEM approach on renewable energy materials can enhance students' creative thinking skills. Meanwhile, Istianah (2023) shows that the application of STEM learning makes a positive contribution to the development of elementary school students' problem-solving abilities, especially in the context of environmental problems.

Table 5. Data from Observations of Student Activities in Cycle 1 Learning

Aspects assessed in cycle 1	Criteria				
	1	2	3	4	5
Phase 1 Orientation to the Problem					
1. Students prepare to study					√
2. Pay attention to the delivery of learning objectives					√
3. Sing the National Song wisely					√
4. Connecting known knowledge with the material to be studied (Apperception)		√			
5. Receive delivery of the scope of assessment (Knowledge, skills and attitudes)				√	
6. Receive problems to be solved in the theme (as outlined in the LKPD/through PPT displays)				√	
7. Students are enthusiastic about being involved in problem solving			√		

Table 6. Data from Observations of Student Activities in Cycle 2 Learning

Aspects assessed in cycle 2	Criteria				
	1	2	3	4	5
Phase 1 Orientation to the Problem					
1. Students prepare to study					√
2. Pay attention to the delivery of learning objectives					√
3. Sing the National Song wisely					√
4. Connecting known knowledge with the material to be studied (Apperception)				√	
5. Receive delivery of the scope of assessment (Knowledge, skills and attitudes)					√
6. Receive problems to be solved in the theme (as outlined in the LKPD/through PPT displays)				√	
7. Students are enthusiastic about being involved in problem solving				√	

Information: 1: very poor, 2: Poor, 3: Fair, 4: Good, 5: very good.

The research revealed that students who engage in STEM-based learning are better able to identify problems, analyze relevant information, and find creative and logical solutions. Thus, implementing the STEAM approach in problem-based learning at SD Inpres Tanamodindi Palu not only improves students' science learning outcomes, but also strengthens their ability to solve problems effectively. The correlation between these two studies strengthens the argument that the STEAM approach, which is a development of STEM with the addition of arts elements, has the same, if not greater, potential in motivating students and improving their problem-solving abilities. This approach not only helps students to better understand academic concepts, but also encourages them to develop critical and creative thinking skills that are essential in facing the challenges of the 21st century. This is in line with the research results of Dhitasarifa et al. (2024) which states that there is an influence of STEAM digital teaching materials on improving creative problem solving skills. Learning with the STEAM approach in PBL also encourages each group member to participate in solving problems as seen in the data presented in Table 7.

Table 7. Data from Observations of Student Activities during the Learning Process

Aspects assessed in cycle 2	Criteria				
	1	2	3	4	5
Phase 2 Organizing students to learn					
1. Students work in groups to work on the problems given on the LKPD/through PPT displays)				√	
2. Students share tasks in groups to search for information (knowledge, concepts, theories) from various sources to find solutions to the problems to be solved.					√
3. Students look for alternative solutions to problems based on the knowledge they have.				√	
4. Information obtained from each group member is discussed in the group				√	

Based on the observation results presented in Table 6 above, student activities in seeking information about problem solutions from various sources are classified in the "very good" category. This shows that students have worked effectively in groups to find relevant information and apply the knowledge gained to solve problems.

These skills are very important in learning, especially in developing critical and collaborative thinking skills. According to Sugiarti et al. (2024), the STEAM approach to the Project Based Learning model has a significant effect on learning outcomes for colloid material and can actively involve students in implementing colloid theories and concepts. Izzania (2021) revealed that the integration of Project Based Learning (PjBL) with STEAM can improve scientific literacy in sixth grade students. Chang et al. (2023) revealed that the application of the STEAM approach in PBL for one semester showed a significant increase in the creativity dimension in the experimental group, while the comparison group did not show significant changes. These findings emphasize the importance of the STEAM approach in learning, especially in the PBL context, because it can have a significant positive impact on the development of students' creativity. This increase in creativity also has implications for students' ability to think more innovatively and solve problems in more effective ways.

21st Century Skills Development

The integration of the STEAM approach in problem-based learning not only encourages the growth of creative thinking and teamwork, but also fosters other 21st century skills, such as critical thinking and communication. The results of observations regarding the application of this approach show an increase in students' ability to find alternative solutions to problems based on the knowledge they have, from cycle 1 with the 'sufficient' category to cycle 2 with the 'good' category.

This is in line with research conducted by Astriani et al. (2023) which shows that the combination of PjBL and STEAM can foster student collaboration in knowledge creation, concept development, and the use of critical thinking in analysis and problem solving. These skills are seen in student activities that require them to solve real problems and present the solutions they find. Zahro et al. (2024) revealed that there was a significant increase in problem-solving skills and creativity in the application of PjBL-STEAM learning. The results of observations from this study also showed an increase in students' abilities in presenting the results of their group work in front of the class, where in cycle 1 the ability was in the "sufficient" category, while in cycle 2 it increased to the "good" category. This is in line with the research results of Ortiz et al. (2023), which show that the application of the STEAM approach can activate learning and increase activities in the teaching and learning process. Through this approach, students are trained to analyze problems in depth, evaluate information from various sources, and develop innovative solutions that are relevant to the real world. Triprani et al. (2023) stated that the STEAM method using the Project-based Learning (PjBL) learning model can improve students' capacity in solving problems in science courses, especially those related to alternative energy. In addition, Rasmi et al. (2025) stated that STEM integrated problem-based web-based worksheets have an effect on students' collaboration skills.

Additionally, the collaboration that occurs during the learning process allows students to work in teams, share ideas, and learn to appreciate different perspectives, which is very important in today's world of work. Communication is also a key skill to hone, as students need to present their work effectively to teachers and classmates. These presentations require them to articulate their ideas clearly, use strong data and arguments, and answer questions with confidence.

Thus, the STEAM approach to problem-based learning not only equips students with academic knowledge and skills, but also prepares them to face complex challenges in the future, both in the context of further education and professional careers.

Conclusion

Based on the data analysis results, it can be concluded that the implementation of the STEAM approach in the PBL model at SD Inpres Tanamodindi can improve students' learning outcomes from 64.65 in cycle 1 to 71.77 in cycle 2 and enhance students' creativity in finding solutions to science problems from the "moderate" category in cycle 1 to the "excellent" category in cycle 2.

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Author Contributions

M. R., S. M and S. N. K contributed in reviewing the latest articles to support the creation of the background and discussion of the research results; S. M and I. J. N. made the research instrument (observation sheet of student and teacher activities) that will be used during the implementation of learning and determined the research subjects. S. N. K., and V. M observed the activities carried out by teachers and students during learning. Then reflected on the implementation of learning in each cycle. M. R., E. D., and I. K transcribed the interview results and analyzed the data that had been collected. M. R., I. J. N., E. D., I. K Wrote the Article Draft, Introduction: Background, Research Problem, and Research Objectives, Writing Methodology: Detailing the research methods used, including design, subjects, and data collection procedures.

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Conflicts of Interest

This research was carried out thanks to financial assistance from the PPG FKIP Study Program, Tadulako University. This funding is used in collecting research data, analyzing data and writing articles as a form of reporting. Apart from that, it is also used to publish the results of this research.

References

Alamha, Sukendro, & Indryani. (2025). The Use of the PBL (Problem Based Learning) Model in the Material of Matter and Object Form to Improve Critical Thinking Skills and Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 425–430. https://doi.org/10.29303/jppipa.v11i2.9512

Amir, R. H., & Purwanti, R. Y. (2021). Efektivitas Model Pembelajaran Steam Pada Siswa Kelas Iv Sd. *Jurnal Kajian Pendidikan Dasar*, *6*(1), 1–13. https://doi.org/10.26618/jkpd.v6i1.4166

Ardi, S., & Marlina, L. (2025). Analysis Development E-Worksheet Based PBL-STEM Approach with a Assisted by Nanofiber Membrane Media on Renewable Energy Materials to Improve Students Creative Thinking Abilities. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 466–473.

https://doi.org/10.29303/jppipa.v11i2.8397

Astriani, D., Martini, Rosdiana, L., Fauziah, A. N. M., & Purnomo, A. R. (2023). STEAM-Project Based Learning (PjBL): Efforts to Train Critical Thinking Skills for Prospective Science Teacher. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 7909–7915. https://doi.org/10.29303/jppipa.v9i10.3823

Brecl, J., Kordigel Aberšek, M., Čampelj, B., & Flogie, A. (2024). STEAM Learning As A Base For Developing Communication Skills In Inclusive Schools. *Journal of Baltic Science Education*, *23*(5), 854–866. https://doi.org/10.33225/jbse/24.23.854

Chang, C.-Y., Du, Z., Kuo, H.-C., & Chang, C.-C. (2023). Investigating the Impact of Design Thinking-Based STEAM PBL on Students' Creativity and Computational Thinking. *IEEE Transactions on Education*, *66*(6), 673–681. https://doi.org/10.1109/TE.2023.3297221

Dhitasarifa, I., & Wusqo, I. U. (2024). The Effect Of Steam Approach Digital Teaching Materials On Increasing Creative Problem-Solving Skills. *Turkish Online Journal of Distance Education*, *25*(3), 18–27. https://doi.org/10.17718/tojde.1302079

Hidayanthi, R., Siregar, N. H., Siregar, D. A., & Siregar, H. L. (2024). Implementation of STEAM-based digital learning for students' numeracy literacy in elementary schools. *Research and Development in Education (RaDEn)*, *4*(1), 653–661. https://doi.org/10.22219/raden.v4i1.32663

Istianah, F. (2023). Importance of STEAM Learning Implementation in Elementary School. *KnE Social Sciences*, *8*(8), 76–84. https://doi.org/10.18502/kss.v8i8.13287

Izzania, R. D. S. M. (2021). Pengembangan Bahan Ajar Project Based Learning (PjBL) Terintegrasi Steam Untuk Memfasilitasi Kemampuan Literasi Sains Siswa Kelas VI Sekolah Dasar. *Jurnal Pembelajaran Dan Pengajaran Pendidikan Dasar*, *5*(1), 146–157. https://doi.org/10.33369/dikdas.v5i1.15914

James, A. A. (2022). Designing And Implementing A Science Technology Engineering Arts And Mathematics Programme for Primary School Teachers. *Gamtamokslinis Ugdymas/Natural Science Education*, *19*(2), 97–103. https://doi.org/10.48127/gu-nse/22.19.97

Kasman, K., & Lubis, S. K. (2022). Teachers' Performance Evaluation Instrument Designs in the Implementation of the New Learning Paradigm of the Merdeka Curriculum. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *8*(3), 760. https://doi.org/10.33394/jk.v8i3.5674

Kemmis, S., McTaggart, R., & Nixon, R. (2014). The action research planner: Doing critical participatory action research. In *The Action Research Planner: Doing Critical Participatory Action Research* (pp. 1–200). https://doi.org/10.1007/978-981-4560-67-2

Mater, N., Daher, W., & Mahamid, F. (2023). The Effect of STEAM Activities Based on Experiential Learning on Ninth Graders' Mental Motivation. *European Journal of Investigation in Health, Psychology and Education*, *13*(7), 1229–1244. https://doi.org/10.3390/ejihpe13070091

Muslim, M., Rustaman, N. Y., Siahaan, P., Liliawati, W., & Efendi, R. (2023). Implementation of Participatory Training Model to Develop Teachers' Ability to Design Formative Assessment Instruments in Science Learning. *Jurnal IPA & Pembelajaran IPA*, *7*(1), 97–107. https://doi.org/10.24815/jipi.v7i1.29657

Ortiz, N. A. D., Peña, M. J. D., & Mora, F. E. H. (2023). Development of Skills in Learning a Foreign Language Under a Steam Approach. *2023 International Conference on Computational Science and Computational Intelligence (CSCI)*, 1780–1784. https://doi.org/10.1109/CSCI62032.2023.00294

Priyatno, H., Nazurty, & Sukendro. (2025). The Use of Project-Based Learning Model in Improving Learning Outcomes in IPAS Learning. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 691–695. https://doi.org/10.29303/jppipa.v11i2.9242

Rasmi, D. P., Wibisana, S. S., & Hendri, M. (2025). The Integrating STEM in Hooke's Law and Elasticity Worksheets: Enhancing Student Collaboration and Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 573–581. https://doi.org/10.29303/jppipa.v11i2.10166

Roshayanti, F., Wijayanti, A., Purnamasari, V., & Sari Setianingsih, E. (2022). Analysis of Understanding and Readiness of Elementary School Teachers on the Implementation of the STEAM (Science, Technology, Engineering, Arts, Mathematics) Approach. *KnE Social Sciences*, 125–135. https://doi.org/10.18502/kss.v7i14.11960

Sadiah, R. L., Ali, M. S., & Khaeruddin. (2025). The Influence of Problem-Based Learning Models and Attitudes in Physics on Students' Physics Problem-Solving Abilities. *Jurnal Penelitian Pendidikan IPA*, *11*(2), 153–163. https://doi.org/10.29303/jppipa.v11i2.7277

Sudarti, S., & Diana, D. (2023). Penerapan STEAM Untuk Mengembangkan Kemampuan Kolaborasi Anak Usia Dini. *Jurnal Usia Dini*, *9*(2), 293. https://doi.org/10.24114/jud.v9i2.52533

Sudarti, S., Yuniarti, Y., & Widia, W. E. (2024). Penerapan Pembelajaran STEAM Dalam Mengembangkan Kreativitas Anak Usia Dini. *Jurnal Kajian Anak (J-Sanak)*, *5*(02), 108–119.

https://doi.org/10.24127/j-sanak.v5i02.4917

Sugiarti, S., Sulastri, T., & Fatimah, S. (2024). The Influence Of The Steam Approach On The PjBL Model On Students' Colloid Learning Outcomes. *UNESA Journal of Chemical Education*, *13*(2), 139–147. https://doi.org/10.26740/ujced.v13n2.p139-147

Triprani, E. K., Sulistyani, N., & Aini, D. F. N. (2023). Implementasi Pembelajaran STEAM Berbasis PjBL Terhadap Kemampuan Problem Solving pada Materi Energi Alternatif di SD. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, *2*, 176–187. https://doi.org/10.24246/j.js.2023.v13.i2.p176-187

Wahyudi, A. B. E., Salimi, M., Hidayah, R., Zainnuri, H., & Fajari, L. E. W. (2024). The Improvement of Students' Creative and Collaborative Thinking Skills by Applying STEAM-Integrated Project-Based Learning. *Jurnal Iqra' : Kajian Ilmu Pendidikan*, *9*(1), 16–29. https://doi.org/10.25217/ji.v9i1.4438

Zahro, A. F., Zaulhaq, H. M., Fitri, R., & Khotimah, N. (2024). Pengaruh PjBL-STEAM terhadap Kemampuan Memecahkan Masalah dan Kreativitas Anak Usia 5-6 Tahun. *Murhum : Jurnal Pendidikan Anak Usia Dini*, *5*(2), 513–524. https://doi.org/10.37985/murhum.v5i2.914

Zhong, Y. (2024). Enhancing student engagement of a university EFL class through cooperative learning: an action research. *Region - Educational Research and Reviews*, *6*(9), 1. https://doi.org/10.32629/rerr.v6i9.2623