International Journal on Advanced Science Engineering Information Technology

Vol.15 (2025) No. 2
ISSN: 2088-5334

# STAD Cooperative Learning Model in the Power System Grounding Course

Abrar Tanjung [a,b], Ganefri Ganefri [a,*], Hansi Effendi [a]

[a] *Department of Technology and Vocational Education, Universitas Negeri Padang, Padang, Indonesia*
[b] *Faculty of Engineering, Lancang Kuning University, Pekanbaru, Indonesia*
*Corresponding author: *ganefri@unp.ac.id*

***Abstract*—The STAD type cooperative learning model is a practical educational technology innovation solution that allows students to engage in practical activities. This study aims to analyze the implementation and effectiveness of this model in the power system grounding course. The results obtained by the product in all aspects of the assessment are categorized as very valid, with an average of 0.92. The practical assessment of lecturers has a practical category, and students are also declared practical with an average of 96. The effectiveness of the cooperative learning model has been measured, including aspects of the affective, cognitive, and psychomotor domains, in experimental and control class students who use conventional learning models with cooperative learning, with an average of 86. Descriptive data showed that in the experimental group, the pre-test value was 62 and the post-test value was 86, with a difference of 22, while in the control group, the pre-test value was 64 and the post-test value was 76, with a difference of 12. So, the value in the experimental group was higher than that of the control group. The independent sample t-test analysis results show that the value of Sig. (2-tailed) = 0.000, so it can be stated that the STAD type cooperative learning model is more effective in improving student learning outcomes in the Power System Grounding course, so that it can be a practical choice of learning model in the future.**

***Keywords*—System grounding; cooperative learning; R&D model.**

*Manuscript received 28 Sep. 2024; revised 19 Jan. 2025; accepted 26 Mar. 2025. Date of publication 30 Apr. 2025.*


## I. INTRODUCTION

The majority of the labor that people formerly performed is now completed by machines with ever-more-advanced technology, which means that changes in the educational process are necessary as a result of the growth of information and communication technology in the twenty-first century [1], [2]. As a result of these developments, all nations must now be able to adapt their educational systems to impart knowledge depending on how technology is used and developed in the twenty-first century. The environment in which individuals reside significantly impacts their mindset, mental attitude, and behavioral habits. People who reside in cities with good access to communication networks will likewise have little trouble adjusting to the modern world [3], [4]. Education is a key element in any society's development, constantly evolving to meet the changing needs and demands of the times. In modern education, approaches that focus on active student engagement in the learning process are increasingly gaining attention [5], [6], [7]. The importance of cooperative learning lies in its ability to foster social, communication, and teamwork skills among students [2], [8]. In today's globalized world, these skills are essential for preparing students to navigate a complex and interconnected world [9].

The STAD (Student Teams Achievement Divisions) learning model is one of the effective cooperative learning models in improving student learning achievement by involving teamwork, individual work, and evaluation of learning outcomes. Although STAD can be applied in various courses, its implementation in more technical courses, such as the Power System Earthing Course, requires special treatment compared to other courses [10], [11], [12]. Overall, the application of the STAD model in the Power System Earthing Course emphasizes more on the aspects of technical practicum, mathematical calculations, and technical skill-based collaboration in solving problems, which makes it more complex compared to other courses that are more theory-based or conceptual analysis [10], [13], [14]. In this case, students need to master the material in depth, teach each other technical concepts to other team members, and ensure proper application of the learned theory.

The most outstanding model for teachers who are just beginning to use a cooperative approach is STAD, which is among the most basic cooperative learning models. The Student Teams Accomplishment Division, or STAD, is the student team accomplishment division. According to the STAD learning model, it is an instructional approach used by the teacher to form a team with a variety of abilities to practice learning concepts and skills together [15], [16]. Slavin, the most incredible model for teachers just beginning to use a cooperative approach, is STAD, one of the most basic cooperative learning models. The student team accomplishment division is known as the Student Teams Accomplishment Division, or STAD for short. Robert Slavin and associates at Johns Hopkins University created this concept [16], [17], [18]. The fundamental goal of STAD is to empower students to support and assist one another in mastering the skills that the teacher is teaching. According to Slavin, the STAD learning model is an instructional approach used by the teacher to form a team with a variety of abilities to practice learning concepts and skills together [19], [20].

Conventional learning refers to a more traditional teaching method in which the lecturer is the primary conveyor of information through lectures, while students are more passive in receiving the material. Conventional learning can positively and negatively impact students' academic achievement and motivation in the Power System Grounding course context. Student achievement refers to conventional learning emphasizing theory and clear structure, which helps students understand the basic concepts in Power System Grounding. However, it can limit students' practical application skills and does not stimulate their ability to think critically or creatively in solving problems. While student motivation refers to conventional learning, it can demotivate students due to a lack of active engagement, monotonous repetition of material, and a lack of use of technology to enhance interactivity. Students may feel bored or inhibited in connecting theory with practice.

To overcome this negative impact, lecturers must implement more diverse learning approaches, such as cooperative-based learning or technology in education, which can better activate students and provide more in-depth practical experience. They must also integrate technology-based practicum and simulation so that students can apply the knowledge gained in theory. Implement active learning methods, such as group discussions, case studies, or digital tools, to increase student engagement. Increase the use of technology-based tools and applications in learning so that students are more motivated and can learn more interestingly and innovatively. The learning approach of Power system grounding, which is centered on lectures and theoretical lectures, makes the study tedious and monotonous. This is the driving force for this research. As a result, learning outcomes and student motivation are subpar, and they fail to graduate competently [21], [22].

## II. Materials and Methods

### A. The Grounding in Power Systems Course

Grounding (earthing) in power systems is crucial in designing and operating electrical networks. The purpose of grounding is to ensure the safe and reliable operation of the electrical system and protect both equipment and personnel from potential electrical hazards. The primary function of grounding in power systems is to safely direct unwanted electrical currents, such as fault currents or lightning strikes, into the ground, thereby preventing dangerous voltage levels that could potentially harm people or damage equipment [21], [23].

### B. The STAD (Student Teams Achievement Divisions) Cooperative Learning Model

The STAD (Student Teams-Achievement Divisions) cooperative model is one of the practical learning strategies to increase student involvement in collaborative learning. Applying the STAD model in the Power Grounding System course can help students understand complex technical concepts through teamwork and active interaction in the classroom. Advantages of STAD Model Implementation in Electrical Power Grounding System Course:

1) *Enhance Collaboration*: Students learn to work in teams, share knowledge, and help each other to solve complex problems.

2) *Deeper Understanding:* Students understand the material theoretically and practically in its application by discussing the material in groups and being given individual quizzes.

3) *Increase Motivation:* Giving points in groups and individually can motivate students to participate and try their best to master the material actively.

4) *Improve Communication Skills:* Group discussions improve students' ability to communicate technically, which is needed in the world of work, especially in electrical engineering.

The application of the STAD-type cooperative model in the Electric Power Grounding System course can increase students' involvement in learning and help them to understand essential concepts in the grounding system better [24], [25], [26]. Student Team Achievement Division (STAD) is a cooperative learning paradigm that employs small groups with 4-5 students in each group. STAD is a collaborative learning approach that blends debate, questioning, and lecturing techniques [27], [28], [29].

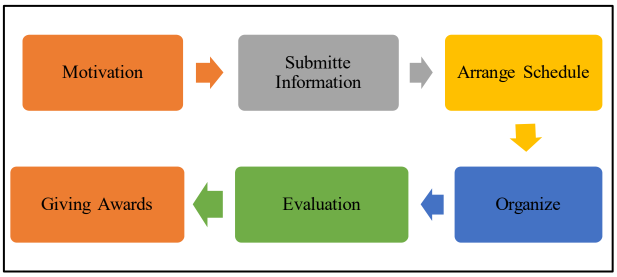


Fig. 1 Syntax of the Cooperative Model

Fig. 1 The Cooperative STAD Model yielded six syntaxes: (1) Inspiration, (2) Transmitting Data, (3) Set up the schedule, (4) Planning, (5) Assessing, and (6) Presenting Prizes [23].

### C. Research and Development (R&D) ADDIE Method

This study aims to develop a cooperative learning model for the Electrical Grounding System course using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) research and development method [30], [31].

This approach aims to improve the product validity, practical skills, and effectiveness of students in the safe grounding system course through collaborative group work. The ADDIE stages begin with analyzing learning needs, followed by designing a cooperative learning model that involves active cooperation among students to solve problems related to grounding materials [32], [33]. In the development stage, learning materials are developed, including activity plans that support student interaction. The model is then tested in the implementation stage to evaluate its effectiveness in enhancing students' understanding of the material and practical skills [34], [35]. The trial results are analyzed in the evaluation stage to assess the model's success and identify necessary improvements. The findings indicate that implementing the ADDIE-based cooperative learning model can enhance students' academic performance and learning motivation. [36], [37], [38].

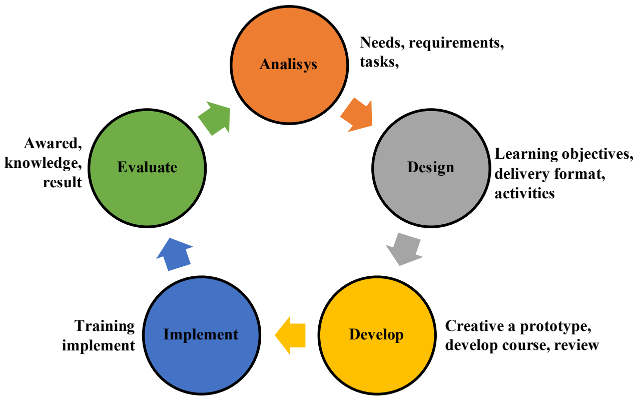


Fig. 2 Development of ADDIE Steps

## III. Results and Discussion

### A. Needs Analysis

In the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) with the Cooperative Learning Model STAD (Student Teams-Achievement Divisions) for the course Electrical Power System Grounding, the needs analysis stage plays a crucial role in ensuring that the learning experience is effective for both students and instructors. Identifying the specific learning needs of both students and instructors is essential to successfully implementing the STAD model in this technical subject [39].

*1) Students' Learning Needs:* Students in the Electrical Power System Grounding course have specific learning needs that must be understood for the STAD cooperative learning method to be applied effectively.

a. Academic Needs (Theory and Concepts):

- Understanding Theory and Practical Applications: Students need to have a solid understanding of the fundamental theories of grounding in electrical power systems, as well as how these concepts are applied in real-world scenarios. They need opportunities to connect theoretical knowledge to practical field applications, such as understanding how grounding systems are used in industry.
- Problem-Solving in Technical Contexts: In STAD, students often work in teams to solve problems or case studies. For a technical course like grounding systems, students need the ability to analyze technical problems, make accurate calculations, and use appropriate tools and equipment to assess grounding systems.
- Practical Skills and Hands-On Experience: Grounding in electrical power systems is a convenient subject. Students need opportunities to work directly with instruments, measurement tools, and electrical systems. Hands-on experience with measurements and analysis will deepen their understanding of the material.

b. Social and Interaction Needs:

- Effective Teamwork Skills: The STAD cooperative learning model requires students to work effectively in teams. Students need teamwork skills, such as discussing, sharing tasks, and solving problems collaboratively. They also need to understand the importance of active group participation for collective success.
- Active Engagement in Learning: Students need motivation to engage actively in the learning process. They need to feel valued and given opportunities to contribute to group discussions, experiments, and team presentations.
- Individual and Group Assessment Needs: Students need to understand the assessment system used in STAD, where they are evaluated based on both individual contributions and team performance. Clear guidelines about how assessments will be conducted for both group tasks and personal achievements are necessary.

c. Technology and Resource Needs:

- Access to Learning Technologies: Students need technological learning resources, such as simulation software for analyzing grounding systems, video tutorials, or online learning platforms. Technology can help enhance their understanding of complex technical concepts.
- Relevant Learning Materials: Students need textbooks, scientific articles, and course materials that provide in-depth coverage of the subject matter. Materials related to grounding systems, industry standards, and best electrical power system installation practices are crucial.

*2) Instructors' Learning Needs:* Instructors who teach the Electrical Power System Grounding course using the Cooperative Learning STAD model also have specific learning needs to ensure the successful implementation of this method.

a. Needs in Designing and Implementing Learning:

- Designing Collaborative and Engaging Learning: Instructors must design learning activities that integrate theory with practical applications and facilitate student collaboration. They must ensure that the tasks assigned are relevant to the material and allow students to think critically and solve problems together.
- Clear Learning Structure: Instructors need to have a solid understanding of how to structure STAD activities, including how to divide students into teams, assign tasks, and implement assessments that measure both individual progress and team achievements.

b. Classroom Management and Group Coordination Needs:
- Managing Group Dynamics: In STAD, instructors must ensure students work effectively in groups. They need to monitor group dynamics, address any conflicts, and encourage equal participation from all group members. This ensures that the cooperative learning model leads to maximum student engagement.
- Facilitator Role: Instructors must act as facilitators during group work, providing guidance and clarification when necessary. They should be available to assist students during experiments, help resolve technical issues, and ensure that the students are staying on track.

c. Needs for Assessment and Feedback:
- Effective Assessment for Group and Individual Work: Instructors must design an assessment system that fairly evaluates group performance and individual contributions. This requires a balanced approach, considering the performance of the entire team as well as how much each individual contributes to the group's success.
- Providing Constructive Feedback: Instructors must provide clear, timely, and constructive feedback to students about their performance in both group tasks and individual assessments. Feedback helps students understand their strengths and areas for improvement, motivating them to enhance their learning.

d. Needs for Using Educational Technology:
- Utilizing Technology to Support Learning: Instructors need to effectively use educational technology, such as simulation tools or software for grounding system analysis, which can assist students in visualizing complex concepts and engaging with the material more interactively.
- Developing High-Quality Learning Resources: Instructors require access to up-to-date learning materials and resources that align with the latest industry practices. These resources can include videos, articles, and simulations that enrich the student learning experience.

## *B. Results of Learning Model Design*

Five experts in model, evaluation, language, and material were given a validation questionnaire to conduct the validity test. The questionnaire provided and the validator's judgment agreed. Language use, learning model layout, and media quality were the aspects that media specialists validated. In the meantime, a Likert scale was used to validate the material element based on factors related to material quality and utility.

TABLE I
RESULTS OF MODEL AND LANGUAGE EXPERT VALIDATION

| No | Aspect of Assessment | Validation Value | Category |
|---|---|---|---|
| 1 | Model Quality | 0.87 | valid |
| 2 | Language Use | 0.89 | valid |
| 3 | Layout | 0.88 | valid |
| | Average | 0.88 | valid |

Table 1 displays the findings from the media and material experts' validation of the learning model.

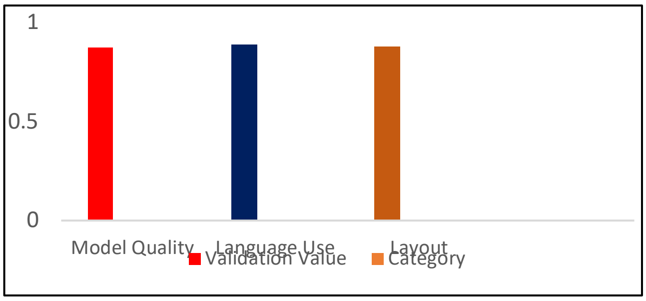


Fig. 3 Results of Model and Language Expert Validation

Figure 3 shows that it is very valid, with a model quality value of 0.87, language use of 0.89, and layout of 0.88.

TABLE II
RESULTS OF MATERIAL EXPERT VALIDATION

| No | Aspect of Assessment | Validation Value | Category |
|---|---|---|---|
| 1 | Material Quality | 0.93 | valid |
| 2 | Material Utilization | 0.91 | valid |
| | Average | 0.92 | valid |

Table 2 shows the Material Expert Validation Results: material Quality of 0.93, Material Utilization of 0.91, and an Average of 0.92. The material expert validation results yielded an average of 0.92 with a valid category.

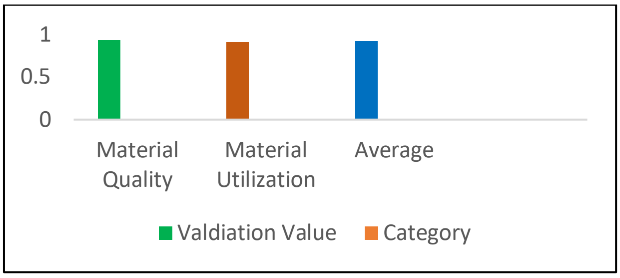


Fig. 4 Results of Material Expert Validation

Fig. 4 Material Expert Validation Results resulted in Material Quality of 0.93, Material Utilization of 0.91 and an Average of 0.92, while the material expert validation results yielded an average of 0.92 with a valid category.

## *C. Data Analysis for Pragmatics*

Tables 3 and 4 display the results of the practicality test, which was derived from lecturers and students filling out the practicality scores of the learning model through a practicality questionnaire sheet completed by 40 students who have taken power system grounding and two lecturers who teach power system grounding. Table 3: Findings from Lecturers' Applicability of the Learning Model Survey

TABLE III
RESULTS OF LEARNING MEDIA PRACTICALITY BY LECTURERS

| No | Aspects Assessment | Average (%) | Criteria |
|---|---|---|---|
| 1 | Student interest | 96 | Very practical |
| 2 | Usage process | 95 | Very practical |
| 3 | Increasing student activity | 98 | Very practical |
| 4 | Time efficiency | 98 | Very practical |
| | Average | 96.8 | Very practical |

In Table 3, the Results of Practicality of Learning Media by Students' Appearance show a value of 94, Usability with a value of 96, and Time efficiency with a value of 98, while the average is 96. Average of 96,8.

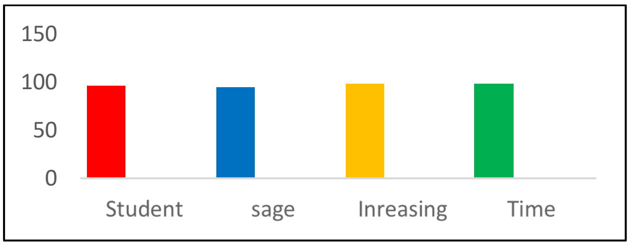


Fig. 5 Results of Learning Media Practicality by Lecturers

Fig.5 shows the results of the Practicality of Learning Media by Lecturers: Student interest with a value of 96, the process of using a value of 95, increasing student activity value to 98, time efficiency value 98, and an average of 96.8.

TABLE IV
RESULTS OF LEARNING MEDIA PRACTICALITY BY STUDENTS

| No | Aspects Assessment | Average (%) | Criteria |
|---|---|---|---|
| 1 | Appearance | 94 | Very practical |
| 2 | Usefulness | 96 | Very practical |
| 3 | Time efficiency | 98 | Very practical |
| | Average | 96 | Very practical |

Table 4 above suggests that lecturers' practicality received an average score of 96.8% using efficient criteria, while students received an average score of 96% using convenient criteria.

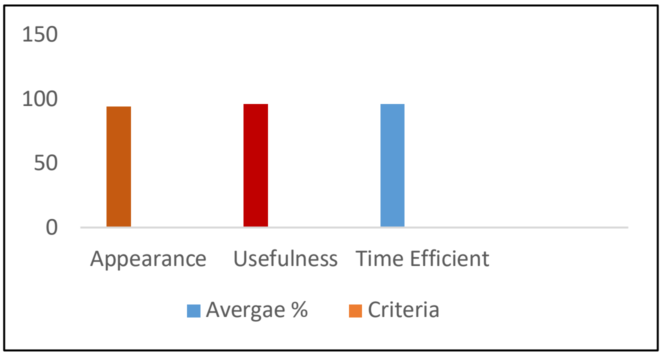


Fig. 6 Results of Learning Media Practicality by Students

In Fig.6, the results of the practicality of learning media by students' appearance show a value of 94, usability with a value of 96, and time efficiency with a value of 98, while the average is 96. average of 96.8

*D. Effectiveness Data*

The two samples from which the research data were derived were the control and experimental classes. The learning model's four meetings were used to instruct the experimental class. The control group used traditional media, and the learning process remained unchanged. Each class received a pretest and posttest with twenty multiple-choice questions and four alternative responses. According to the pretest findings, the experimental class, which consisted of 20 students, scored the highest (86), lowest (50), and averaged 68 for power system grounding. On the other hand, the 20-student control class got an average score of 71.5, the highest score of 88, and the lowest score of 55. Based on the data obtained from the posttest results, the experimental class group consisting of 20 students had an average score of 78.5, the lowest score of 60, and the maximum score of 97 on power system grounding. The most score a single student could achieve in the control class of 20 was 98, the lowest was 62, and the average score for the control class was 80.

TABLE V
POST AND PRE TEST RESULTS

| No | Group | Pre Test | Post Test | Difference |
|---|---|---|---|---|
| 1 | Experimental Class | 62 | 84 | 22 |
| 2 | Control Class | 64 | 76 | 12 |

Table 5 Post Test and Pre Test Results with details of the Experimental Class Pre Test results 62, Post Test 84, and a difference of 22. While the Control Class Pretest results were 64, the Post Test results were, and the difference was 12.

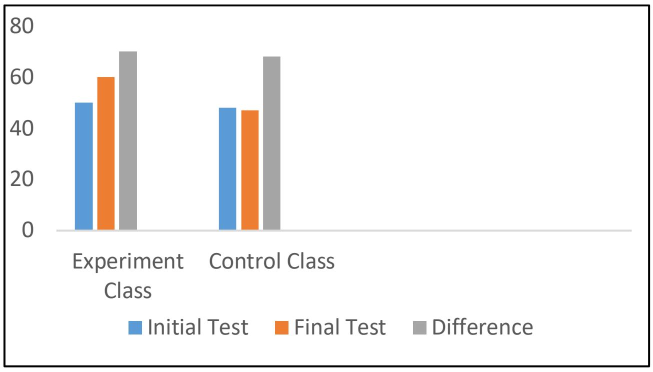


Fig. 7 Post and Pre-Test Results

In Fig.7, Post Test and Pre Test Results with details of the Experimental Class Pre Test results 62, Post Test 84, and a difference of 22. While the Control Class Pre test results were 64, the Post Test results were, resulting in a difference of 12. Students who used the learning model yielded final test results with an average score of 74, with a standard deviation of 13.08, the highest score being 50, and the learning outcomes of those students being 98.

TABLE VI
LISTS THE EXPERIMENTAL CLASS LEARNING OUTCOME scores

| No | Class Interval | Midpoint | Frequency |
|---|---|---|---|
| 1 | < 50 | 48 | 1 |
| 2 | 51 - 59 | 57 | 2 |
| 3 | 60 - 69 | 68 | 4 |
| 4 | 70 - 79 | 76 | 10 |
| 5 | 80 - 100 | 80 | 3 |

Table 6 shows the interval score range for student learning outcomes 70-79 with a midpoint of 76 and a frequency of 10, and 80-100 with a midpoint of 80 and a frequency of 3 in grounding the power system in the experimental class.

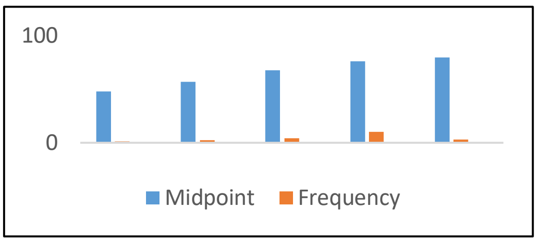


Fig. 8 Lists of the Experimental Class Learning Outcome Scores

Figure 8 shows the interval score range for student learning outcomes 70-79 with a midpoint of 76 and a frequency of 10, and 80-100 with a midpoint of 80 and a frequency of 3 in grounding the power system in the experimental class. The scope of Table 7 displays the student learning outcome score intervals for power system grounding in the control class.

TABLE VII
CONTROL CLASS LEARNING OUTCOME SCORE DATA

| No | Class Interval | Midpoint | Frequency |
|---|---|---|---|
| 1 | < 50 | 49 | 0 |
| 2 | 51 - 59 | 58 | 2 |
| 3 | 60 - 69 | 66 | 6 |
| 4 | 70 - 79 | 76 | 10 |
| 5 | 80 - 100 | 81 | 2 |
| | Amount | | 20 |

Table 7 above shows that the interval class with the highest frequency, 10, is in the range 70-79, with a midpoint of 76. The table above also shows the interval of students who obtained learning outcomes with scores between 50 and 100.

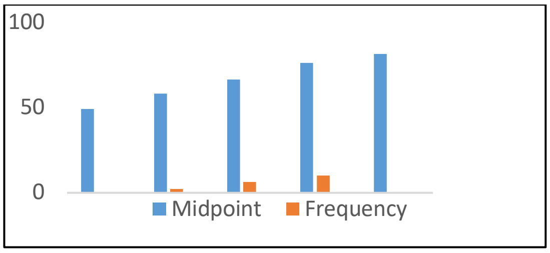

Fig. 9 Control Class Learning Outcome Score Data

Fig. 9 above indicates that the interval class with the highest frequency, 10, is in the range 75-84. The average value of the collected data is 75.5. The interval of student scores that earned learning outcomes with scores between 45 and 100 can be observed in the above table.

Based on the reasoning mentioned earlier, it can be inferred that the Electrical Engineering Study Program at Lancang Kuning University's Faculty of Engineering has found substantial success in using learning models for power system grounding. It is said that the table value of 2.021 is less than the t-count of 2.202. A measurement of a measuring instrument's validity or reliability is called validity. The validator's assessment of the reliability of the produced media provides validation for the learning model. There are two media experts and three material validators that make up this media validator. Questionnaires, consultations, and conversations were collected by displaying the initial version of the media developed, based on the validity test of the learning model.

Media materials and design are among the factors noted in the validity test of learning media. An average score of 0.85 with a valid category was obtained for media validation from media professionals, while 0.9 with a valid category was acquired for material validation. The learning model was revised in light of recommendations and evaluations from media specialists who served as validators. When evaluating the validity of a learning medium, the resulting learning model has satisfied the requirements for a good media.

Twenty students who had studied power system grounding participated in the study program for electrical engineering at the Faculty of Engineering, where the practicality data of the learning materials were collected. One instructor who taught power system grounding completed a questionnaire assessing the learning model's practicality, and the results showed an average score of 96% using very practical criteria. A very practical set of criteria led to an average score of 84% for the practicality analysis, which was based on a questionnaire completed by 32 students. From the average score obtained by the lecturer on the practicality test and from the average score obtained by the students on the practicality test, it can be inferred that the power system grounding learning model generated is very practical It has been demonstrated to be incredibly useful by the Faculty of Engineering's Electrical Engineering Study Program. Thus, the learning model can be disseminated and applied in the learning process, provided it has been deemed feasible.

Twenty students were in the experimental class and twenty students were in the control group when the study was implemented, totaling forty samples. There was a significant difference in learning outcomes between students who used the learning model and students who did not use the learning video, at a significance level of α 0.06, after testing the hypothesis using the data collected throughout the study. The hypothesis test findings indicate that the application of the learning model in power system grounding improves student learning outcomes in the Faculty of Engineering's Electrical Engineering Study Program.

The data processing findings show several aspects linked to the hypothesis that have been put out, including pupils in the experimental and control groups had nearly identical starting skills and were subjected to distinct learning strategies—the experimental group learned models, while the control group used traditional media. The experimental class outperformed the control class in terms of student learning outcomes in the knowledge area, indicating that the use of learning models in the classroom influences student learning. Additionally, the experimental class outperformed the control group in terms of practical values and increased. The pretest averages in the control group were higher than those in the experimental group. But following the posttest, there was little improvement in the control class's scores, as shown by the disparity in the rise in the experimental class's kids' pretest and posttest results.

A comparative analysis is conducted to determine whether the views of experts and students align or if there are significant differences. Several aspects that can be compared include:

- Effectiveness of the model in achieving learning objectives.
- Suitability of the methods used to meet student needs.
- Improvement in student motivation, as seen through the level of engagement and enthusiasm in learning.
- Ability to address learning challenges, from the perspective of experts who view it from the theoretical and structural side, and from the perspective of students who experience it firsthand.

## IV. CONCLUSION

Based on the results of the discussion of the STAD type cooperative learning model using the ADDIE method, the following conclusions are obtained STAD type cooperative learning in the Power System Grounding course is made by applying the Research and Development method, Product validity and support in the Power System Grounding course include STAD type cooperative learning model books, textbooks, lecturer guidebooks, and student guidebooks. Products in all aspects of the assessment are categorized as very valid with an average of 0.92, as evidenced by the analysis using the instrument test, so it is concluded that the STAD type cooperative learning model can be applied in learning, The practicality of the STAD type cooperative learning model can be seen from the overall implementation of the use of the model well. The results obtained from lecturers have a practical category, and the results of student practicality are also declared practical, with an average of 96. The effectiveness of the STAD type cooperative learning model has been measured, including aspects of the affective, cognitive, and psychomotor domains, in experimental and control class students who use conventional learning models with STAD type cooperative learning, and the results prove that the STAD type cooperative learning model is more effective, with an average of 86.

Descriptive data shows that in the experimental group, the pre-test value is 62 and the post-test value is 86, with a difference of 22, while in the control group, the average pre-test value is 64 and the post-test value is 76, with a difference in value of 12. So the value in the experimental group is higher than that in the control group. The independent sample t-test analysis results show that the value of Sig. (2-tailed) = 0.000, so it can be stated that the STAD type cooperative learning model is more effective in improving student learning outcomes in the Power System Earthing course so that it can be a flexible choice of learning model in the future. Furthermore, this research contributes to technological learning innovation and the development of flexible learning models.


## ACKNOWLEDGEMENTS

We thank the Head and Lecturers of the Electrical Engineering Study Program for permission to use the student data provided.


## REFERENCES


[1] S. Z. D. Chamidah et al., "Navigating the global landscape on project based learning and 21st-century skills research (2020-2023): A bibliometric analysis," *Malays. J. Learn. Instr.*, vol. 21, no. 2, 2024.

[2] V. A. N. B. Sulfiani et al., "Increasing student learning interest through cooperative learning," *J. La Edusci*, vol. 5, no. 24, 2024.

[3] R. Z. Ikhlas et al., "Utilization of Canva application as a learning media video creation," *J. Soc. Sci. Util. Technol.*, vol. 1, no. 3, pp. 158-169, 2023.

[4] K. Mohd Salleh, N. L. Sulaiman, and G. Gloeckner, "Exploring test concept and measurement through validity and reliability process in TVET research: Guideline for the novice researcher," *J. Tech. Educ. Train.*, vol. 15, no. 1, pp. 257-264, 2023, doi:10.30880/jtet.2023.15.01.022.

[5] D. Zitkeviciene and J. Lasauskienė, "The method of involving young children in group musical activities," in *Proc. Hum., Technol. Qual. Educ.*, 2023.

[6] S. W. Kolluri et al., "Machine learning and artificial intelligence in pharmaceutical research and development: A review," *AAPS J.*, vol. 24, pp. 1-10, 2022.

[7] J. Adri et al., "Critical thinking skills in performance-based assessment: Instrument development and validation," *J. Tech. Educ. Train.*, vol. 14, no. 1, pp. 91-100, 2022, doi:10.30880/jtet.2022.14.01.008.

[8] R. G. T. Tadesse, H. Ware, and A. Asmare, "Enhancing student engagement and outcomes: The effects of cooperative learning in an Ethiopian university's classrooms," *J. Educ. Sci.*, vol. 14, no. 19, 2024.

[9] M. P. Gupta and M. Agrawal, "Compression of deep learning models for text: A survey," *ACM Trans. Knowl. Discov. Data*, vol. 16, no. 4, 2022.

[10] W. S. S. Muhamad Firdaus Bin Rini, M. H. Bin Ahmad, and I. Bin Mohd, "Implementation of cooperative script model in teaching Islamic education in elementary school," *Int. J. Multidiscip. Res. High. Educ.*, vol. 7, no. 1, 2024, doi: 10.24036/ijmurhica.v7i1.167.

[11] M. F. M. Kamal et al., "Identification of cooperative learning component in designing lesson plan for building drawing subject in vocational colleges," *J. Tech. Educ. Train.*, vol. 15, no. 1, pp. 20-27, 2023, doi: 10.30880/jtet.2023.15.01.003.

[12] B. Öztürk, "The effect of cooperative learning models on learning outcomes: A second-order meta-analysis," *Educ. Policy Anal. Strateg. Res.*, vol. 18, no. 23, 2023.

[13] H. S. Rad and E. Namaziandost, "Integrating STAD and flipped learning in expository writing skills: Impacts on students' achievement and perceptions," *J. Res. Technol. Educ.*, vol. 5, no. 4, 2023.

[14] I. Fonseca et al., "Gamification and game-based learning as cooperative learning tools: A systematic review," *Int. J. Emerg. Technol. Learn.*, vol. 18, no. 21, 2023.

[15] R. M. Gillies, "Using cooperative learning to enhance students' learning and engagement during inquiry-based science," *Educ. Sci.*, vol. 13, no. 12, p. 1242, 2023, doi: 10.3390/educsci13121242.

[16] O. P. N. Sukontawaree and A. Poonputta, "Development of problem-solving abilities in science by inquiry-based learning with cooperative learning for grade 4 students," *J. Educ.*, vol. 8, no. 2, 2022, doi:10.5296/jei.v8i2.20418.

[17] S. A. M. Hamadi and J. El-Den, "Integrating social media as cooperative learning tool in higher education classrooms: An empirical study," *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 24, no. 6, 2022.

[18] G. M. Geletu, "The effects of teachers' professional and pedagogical competencies on implementing cooperative learning and enhancing students' learning engagement and outcomes in science," *Cogent Educ.*, vol. 9, no. 1, 2022.

[19] E. N. C. Anidi and I. Obumneke-Okeke, "Effect of cooperative learning on primary school pupils' reading achievement in Awka metropolis," *J. Plus Educ.*, vol. 30, no. 1, 2022.

[20] Y. Warmi et al., "An optimal design of grounding system for tower footings in Payakumbuh 150 kV transmission line of Koto Panjang," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 13, no. 3, pp. 835-841, 2023, doi: 10.18517/ijaseit.13.3.17273.

[21] S. Melinia and N. Nugroho, "Creating a video using Canva application as an English learning media of recount text material," *J. English Educ.*, vol. 2, no. 2, pp. 118-129, 2022.

[22] H. Halimoon, M. I. Mukhtar, and R. Roddin, "Instrument's validity and reliability for assessing teaching practicum: A case study in construction technology at vocational colleges," *J. Tech. Educ. Train.*, vol. 13, no. 3, pp. 162-171, 2021, doi: 10.30880/jtet.2021.13.03.016.

[23] M. S. H. L. Shobirin, "Efforts to improve the learning outcomes of Islamic education through the cooperative imprisonment model of students teams achievement division," *Soc. Lit. Study Educ.*, vol. 2, no. 1, 2021.

[24] S. D. Ü. Aslan Berzener, "The effect of cooperative learning on EFL learners' success of reading comprehension: An experimental study implementing Slavin's STAD method," *Turk. Online J. Educ. Technol.*, vol. 20, no. 1, 2021.

[25] I. A. de la Peña and D. Cassany, "Student podcasting for foreign language teaching-learning at university," *J. Technol. Sci. Educ.*, vol. 14, no. 1, pp. 123-141, 2024, doi: 10.3926/jotse.2509.

[26] A. Jaiswal, "Characterizing team orientations and academic performance in cooperative project-based learning environments," M.S. thesis, Dept. Educ., Univ. Florida, Gainesville, FL, USA, 2021.

[27] M. A. Hossain, R. A. Tarmizi, and A. F. M. Ayub, "Collaborative and cooperative learning in Malaysian mathematics education," *J. Math. Educ.*, vol. 3, no. 2, pp. 103-114, 2021.

[28] Q. A. Al-Haija and A. Ishtaiwi, "Machine learning based model to identify firewall decisions to improve cyber-defense," *Int. J. Adv. Sci.*

*Eng. Inf. Technol.*, vol. 11, no. 4, pp. 1688-1695, 2021, doi:10.18517/ijaseit.11.4.14608.

[29] Y. Jiang et al., "Revisiting research and development expenditures and trade adjusted emissions: Green innovation and renewable energy R&D role for developed countries," *J. Knowl. Econ.*, vol. 15, no. 1, pp. 2156-2191, 2024, doi: 10.1007/s13132-023-01220-0.

[30] M. J. Bataineh, P. Sánchez-Sellero, and F. Ayad, "Green is the new black: How research and development and green innovation provide businesses a competitive edge," *Bus. Strateg. Environ.*, vol. 33, no. 2, pp. 1004-1023, 2024, doi: 10.1002/bse.3533.

[31] Y. Syafitri and Syafriani, "Need analysis for development of physics e-module integrated with critical reading to enhance critical thinking and scientific literacy in senior high school," *J. Penelit. Pendidik. IPA*, vol. 9, no. 10, pp. 8065-8069, 2023, doi: 10.29303/jppipa.v9i10.4976.

[32] S. M. Yoong et al., "Validity and reliability of needs analysis questionnaire for dyscalculia instrument," *South Asian J. Soc. Sci. Humanit.*, vol. 3, no. 3, pp. 111-124, 2022, doi:10.48165/sajssh.2022.3307.

[33] K. Mathiyalagan, D. Shin, and Y. C. Lee, "Difficulties, strategies, and recent research and development of layered sodium transition metal oxide cathode materials for high-energy sodium-ion batteries," *J. Energy Chem.*, vol. 90, pp. 40-57, Mar. 2024, doi:10.1016/j.jechem.2023.10.023.

[34] S. Mendo-Lázaro et al., "The impact of cooperative learning on university students' academic goals," *Front. Psychol.*, vol. 12, pp. 1-7, Jan. 2022, doi: 10.3389/fpsyg.2021.787210.

[35] J. J. Minviel and F. Ben Bouheni, "The impact of research and development (R&D) on economic growth: New evidence from kernel-based regularized least squares," *J. Risk Financ.*, vol. 25, no. 3, pp. 583-604, 2022, doi: 10.1108/JRF-09-2021-0157.

[36] A. Jaiswal, T. Karabiyik, and P. Thomas, "Characterizing team orientations and academic performance in cooperative project-based learning environments," *Educ. Sci.*, vol. 11, no. 9, 2021, doi:10.3390/educsci11090520.

[37] T. N. M. Arfa and I. Akhmad, "Different effects between cooperative and sociometric learning on lower passing learning outcomes in volleyball games of grade VIII students at SMP Negeri 14 Medan," *Adv. Soc. Sci. Educ. Humanit. Res.*, vol. 384, 2021, doi:10.2991/aisteel-19.2019.105.

[38] S. U. S. Aisyah and I. P. Dewi, "Cooperative learning and case-based learning to improve spiritual care competency in nursing students," *Indones. Nurs. J. Educ. Clin.*, vol. 7, no. 2, 2022, doi:10.24990/injec.v7i2.516.

[39] C. Dimitra Filippou, C. Buchs, and A. Quiamzade, "Understanding motivation for implementing cooperative learning methods: A value based approach," *Soc. Psychol. Educ.*, vol. 25, 2022, doi:10.1007/s11218-021-09666-3.