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ARTICLE

Implementing cooperative learning model with peer tutoring to enhance understanding of Wave concepts in high school

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Abstract

The difficulty of presenting teaching aids in the classroom makes it challenging for students to understand the material on sound waves, as sound waves are difficult to observe with the naked eye. Therefore, a learning model that facilitates student comprehension of sound waves is needed. This study aims to investigate the impact of a cooperative learning model using peer tutoring on students' understanding of sound wave concepts. The research method employed is quantitative, utilizing a quasi-experimental design with a nonequivalent control group. The study involved 76 students divided into experimental and control classes. The instrument used was a multiple-choice test consisting of 15 questions. The study was conducted over three sessions, starting with a pre-test in the first session and concluding with a post-test in the final session to determine the effect of the tested variable. The results indicate that the cooperative learning model with peer tutoring significantly affects students' conceptual understanding, with an average score of 64.04 in the experimental class compared to 53.86 in the control class. Additionally, the N-Gain test results show 41% improvement, categorized as moderate. Analysis of concept comprehension revealed an increase in understanding, with approximately 88.16% of students mastering the interpretation aspect of the concept.

Keywords: Cooperative learning, Peer tutoring, Wave concepts

1. Introduction

A sound wave is a type of wave that can propagate quickly through a medium. It is classified as a longitudinal and mechanical wave. Sound waves are a topic studied in physics. They have numerous applications in human life, such as ultrasonography, sonar, and echocardiograms. However, these technologies are not easily encountered in everyday life, making it challenging to teach this material to students without demonstrations or tools to aid in explaining sound waves. Without concrete explanations, students find it difficult to understand the material on sound waves because these waves cannot be seen with the naked eye.

In addition to the difficulty of presenting applications related to sound waves, the method typically used in the classroom is lecturing. There are several drawbacks to using lectures for teaching sound waves. First, students are often engaged in rote memorization, which does not provide meaningful learning experiences. Second, the learning process becomes monotonous as it is one-directional, from teacher to student, causing students to become easily bored in class. Therefore, an appropriate learning model is needed to help students fully understand the concept and to encourage active student participation through various activities. One suitable model is the cooperative learning model with peer tutoring.

The cooperative learning model is well-suited for classroom implementation (Hänze and Berger 2007; Hasanah and Himami 2021). It allows students to play a more active role during the learning process and to engage in learning activities until the end. Research on the impact of the cooperative learning model has been conducted, whose findings indicate that the cooperative learning model positively affects students' ability to understand physics concepts (Anita Dewi Utami, Puput Suriyah, and Novi Mayasari, n.d.).

The cooperative learning model can be implemented with the assistance of peer tutoring. Using peer tutoring, students can better understand the material because it is explained by classmates with similar thought processes and everyday language, making it easier to comprehend. Moreover, there is no awkwardness between tutor and tutee. Research on peer tutoring has shown it successfully motivates students to learn physics, with most students actively participating in classroom activities (Dioso-Henson 2012). Therefore, this study aims to address these issues and provide a solution that educators can use in their teaching practices.

2. Literature Framework

2.1 Cooperative learning model

Learning models can be categorized into several types, such as teacher-centered models, application-focused models, and student-centered models. Among the student-centered models, one prominent example is cooperative learning. Cooperative learning is based on constructivist theory and encourages collaboration among students to achieve learning goals. Cooperative learning is a model that uses group-based learning systems with the aim that students can achieve educational objectives (Agustianto, Soeparmi, et al. 2018). It has several characteristics, including group-based learning, group management, and teamwork skills. Cooperative learning has three important goals: to improve students' academic performance, to teach students to accept individual differences within a group, and to develop cooperation skills among students.

The cooperative learning model is an instructional approach that emphasizes collaboration among students in small groups to achieve common learning goals. In this model, students are not only responsible for their own learning but also for helping their peers understand the material. Cooperative learning aims to enhance social skills, deepen academic understanding, and develop critical thinking abilities. One of the key features of this learning model is the division of roles within the group, where each member has specific responsibilities contributing to the group's overall success (Agommuoh and Ekeoha 2023).

Cooperative learning offers various methods, such as Jigsaw, Think-Pair-Share, and Group Investigation. The Jigsaw method, for instance, divides the lesson material into sections, each studied by one group member. After understanding their part, each member teaches it to the others, ensuring that all members gain a comprehensive understanding of the material. The Think-Pair-Share method encourages students to think individually, then discuss with a partner, and finally share their discussions with the entire class. Group Investigation requires groups to conduct research together, from formulating a problem to presenting their findings (Usman 2015).

2.2 Peer tutoring method

Febianti (2014) explains that peer tutoring is a method involving proficient students in a particular subject who assist other students in the same class to understand the learning material. Peer tutoring is a procedure where students teach other students within the same class. Peer tutoring can be conducted between students of the same age or with significant age differences, as well as between students from different classes (Misdalina, Lefudin, et al. 2020; Febianti 2014). Meanwhile, peer tutoring as a way to help students meet their learning needs. Peer tutoring is a cooperative approach, where involved students gain confidence and pride in their roles and tasks, and their experiences can be educational. When students learn through peer tutoring, they can improve their concentration, listening, and understanding skills by seeing different perspectives on problems and using familiar everyday language.

The peer tutoring method is a learning approach where more experienced students or those with a better understanding of a particular subject guide and assist their peers who need help. This method is based on the principle that students can learn effectively from their peers because communication is often more open and less hindered by age or hierarchical gaps than between teachers and students. Peer tutoring can occur formally or informally, in small groups or one-on-one settings. A key advantage of this method is the enhanced understanding and active engagement of both the tutor and the tutee. Tutors reinforce their knowledge through teaching, known as the tutor effect, which helps deepen their understanding (Gustiawan 2021; Cahyati and Kartika 2019). Meanwhile, tutees receive explanations and support that may be easier to understand due to the familiar language used. Additionally, this method develops social skills, communication, and confidence for all involved students. Peer tutoring can be applied in various educational contexts and levels, from elementary to higher education, and across different subjects. The success of this method depends on selecting appropriate tutors, providing adequate training, and continuous monitoring by teachers to ensure effective and beneficial tutorial sessions. It is also important to consider group dynamics and ensure that the learning process occurs in a positive and supportive environment. Thus, peer tutoring not only enhances academic achievement but also builds a supportive and collaborative learning community among students.

2.3 Conceptual understanding

Conceptual understanding combines the terms understanding and concept. Understanding means to grasp or comprehend, while Duffin and Simpson describe understanding as the ability to comprehend things at a higher level of knowledge (Nieswandt 2007). Understanding is the ability to perceive something from various perspectives. The researchers describe understanding as a conception that students can grasp, allowing them to use and explore related possibilities (Kang 2007). The term concept refers to an idea of real events expressed in definitions, theories, and laws. Anderson and Krathwohl categorize understanding into several aspects: interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining (Utami et al. 2020).

Understanding wave concepts is crucial for high school students as waves are a fundamental concept in physics with numerous applications in everyday life and technology. Wave concepts include various types, such as sound waves and electromagnetic waves, both of which play significant roles in fields like communication, healthcare, and information technology. A deep understanding of wave concepts enables students to grasp how technologies such as radios, televisions, cell phones, and the internet work. Moreover, wave concepts are relevant in medical fields, such as in the use of ultrasonography for medical diagnosis. In an increasingly technology-dependent world, students who understand wave concepts can more easily adapt to new technological developments and use these technologies effectively. Besides practical benefits, understanding wave concepts also enhances students' critical thinking and analytical skills. They learn how to analyze physical phenomena, conduct experiments, and interpret data, which are essential skills for higher education and careers in science, technology, engineering, and mathematics (STEM). Effective teaching methods, such as cooperative learning and the use of teaching aids, can help students better understand these abstract concepts. With a strong understanding of waves, students are not only prepared for academic exams but also for real-life challenges that require scientific thinking and creative solutions. Therefore, teaching wave concepts should be a primary focus in the high school physics curriculum.

3. Research Method

3.1 Research design

This study employs a quantitative method with a non-equivalent control group design. The research involves several samples divided into experimental and control classes. The independent variable in this study is the cooperative learning model using peer tutoring, while the dependent variable is students' conceptual understanding (Sidiq, Choiri, and Mujahidin 2019).

3.2 Participants and research instruments

The study was conducted on 76 eleventh-grade students from a public high school in Garut, who served as the research subjects. There were two class groups: the experimental class and the control class, each consisting of 38 students. The research subjects were selected based on predetermined criteria, such as the experimental class predominantly consisting of students with good collaboration skills, evenly distributed abilities among students, and the ability to follow instructions well (Wulandari 2016). In contrast, the control class comprised students with higher intellectual abilities than those in the experimental class, who were less skilled in collaboration and more capable of independent learning.

The instrument used was a multiple-choice test on conceptual understanding, consisting of 15 questions with five answer choices each. The test questions were written based on conceptual understanding aspects: interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. Each aspect had 2 questions. Before being administered to the sample, the research instrument was validated by two experts.

3.3 Data analysis

The data used for analysis in this study were the pretest and posttest results from both classes, processed beforehand. The first step was descriptive analysis, which involved analyzing the scores obtained by students in each class. Descriptive analysis was conducted using Microsoft Excel 2016. The next step involved conducting normality and homogeneity tests as prerequisites for hypothesis testing. The final step was hypothesis testing using the Mann-Whitney test and performing an N-Gain analysis (Coletta and Steinert 2020) to determine the effect of the cooperative learning model with peer tutoring on students' conceptual understanding. Data analysis was carried out using IBM SPSS version 27.

4. Result of the research

After administering the pretest and posttest to both classes with different treatments, the data were processed using Microsoft Excel 2016 and IBM SPSS version 27. The research results are detailed in the subsequent sections.

4.1 Descriptive analysis of conceptual understanding

The research results were obtained through tests conducted in the form of a written multiple-choice test consisting of 15 questions. The written test was administered to both classes, each receiving different treatments. Each class consisted of 38 students. The first test was a pretest, and the second test was a post-test. These two tests were given to assess the students' abilities and achievements during the treatment period.

Table 1. Pretest and post-test scores

Measurement	Experimental group		Control group	
	Pretest	Posttest	Pretest	Posttest
Number of students	38	38	38	38
Ideal score	100	100	100	100
Minimum score	13.33	40	20	40
Maximum score	60	93.33	73.33	80
Average	**38.25**	**64.04**	**41.58**	**53.86**

The average scores obtained from each class for the pre-test were 38.35 (experimental class) and 41.58 (control class). The mean score for conceptual understanding in the experimental class was 10.18 higher than that of the control class. The experimental class experienced a higher increase in mean pretest to posttest scores compared to the control class. The pretest, serving as a measure of students' initial conceptual understanding, indicated that the initial abilities of students in the control class were higher than those in the experimental class, with a difference in pretest averages of 3.33. After receiving different treatments in both classes, the increase in the average posttest scores of students in the experimental class was higher than that in the control class. If the students' conceptual understanding test scores on the topic of sound waves in both classes are categorized into a five-point scale, the results would be as follows in the following table.

Table 2. Categorization of pretest scores

Interval	Category	Pre-Test			
		Experiment	Percentage	Control	Percentage
81-100	Very high	0	0	0	0
61-80	High	0	0	3	7.89
41-60	Intermediate	12	31.58	10	26.32
21-40	Low	21	55.26	24	63.16
0-20	Very low	5	13.16	1	2.63

Based on the presented data, the results for the pretest in the experimental class show that 13.16% of students were in the very low category, 55.26% were in the low category, and 13.58% were in the moderate category. The highest percentage for pretest scores was in the moderate category, indicating that students' conceptual understanding was at a moderate level before the treatment. For the post-test results in the experimental class, 42.11% of students were in the moderate category, 55.26% were in the high category, and 0.03% were in the very high category. The highest percentage for post-test scores was in the very high category, indicating that students' conceptual understanding after the treatment was in the very high category.

Next, in the control class, for the pretest, 2.63% of students were in the very low category, 63.16% were in the low category, 26.32% were in the moderate category, and 7.89% were in the high category. The highest percentage for pretest scores in the control class was in the high category, indicating that students' conceptual understanding before the treatment was at a high level. Furthermore, for the posttest, 86.84% of students were in the moderate category, and 13.16% were in the high category. The highest percentage for posttest scores in the control class was in the high category, indicating that students' conceptual understanding after the treatment was at a high level.

Table 3. Categorization of posttest scores

Interval	Category	Posttest			
		Experiment	Percentage	Control	Percentage
81-100	Very high	1	0.03	0	0
61-80	High	21	55.26	5	13.16
41-60	Intermediate	16	42.11	33	86.84
21-40	Low	0	0	0	0
0-20	Very low	0	0	0	0

To further understand in detail the influence of the treatment given to both classes on conceptual understanding, an analysis was conducted on students' answers in each class in the test consisting of 15 items. The test comprised seven aspects of conceptual understanding, with each aspect having 2 items, except for the inferring or summarizing aspect, which had 3 items.

After administering the pretest, applying the treatment using peer tutoring, and then conducting the posttest, there was an increase and decrease in students' understanding. Table 4 presents the pretest and posttest data. Almost all students in the experimental class showed an improvement in understanding, as evidenced by the increase in scores from pretest to posttest. Conversely, in the control class, not all students experienced an improvement in understanding. Some students showed a reduction in understanding in certain indicators. Further investigation is needed to explore these findings, as peer tutoring cooperative models could potentially provide an alternative solution for physics learning conducted conventionally.

Table 4. Analysis of each item test of conceptual understanding

Item	Aspect of comprehension	Experimental group		Control group	
		Pretest	Posttest	Pretest	Posttest
1	Classifying	23	37	17	23
2	Exemplifying	4	29	3	2
3	Predicting/Concluding	26	32	34	35
4	Classifying	14	26	7	12
5	Exemplifying	12	14	35	35
6	Summarizing	7	13	3	6
7	Comparing	18	26	35	36
8	Interpreting	11	32	0	13
9	Predicting/Concluding	11	28	5	10
10	Explaining	30	36	33	32
11	Comparing	4	8	2	6
12	Summarizing	21	32	22	34
13	Explaining	5	8	6	25
14	Predicting/Concluding	8	9	2	4
15	Interpreting	24	35	33	34

4.2 Enhancement of conceptual understanding

After conducting calculations using SPSS, the results of the normality and homogeneity tests for the research data were obtained. The normality test results are presented in the following table.

The results indicate that the significance (sig) value for the experimental class data in the Shapiro-Wilk test is greater than 0.05, whereas the control class data has a significance (sig) value less than 0.05. Therefore, the data for the control class is not normally distributed, while the data for the experimental class is normally distributed.

Table 5. The result of normality test

Group	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest (experimental group)	0.957	38	0.147
Posttest (experimental group)	0.954	38	0.118
Pretest (control group)	0.854	38	0
Posttest (control group)	0.776	38	0

A homogeneity test was conducted to determine whether the data from the two groups are homogeneous. The results of the homogeneity test indicated that the significance (sig) based on the mean was 0.880. This shows that the sig mean is greater than 0.05. The conclusion that can be drawn is that the variances of the data from both classes are homogeneous. After obtaining the results from the normality and homogeneity tests, the hypothesis test was then conducted, with the results as follows.

Table 6. The result of normality test

Group	Shapiro-Wilk		
	Statistic	df	Sig.
Pretest (experimental group)	0.957	38	0.147
Posttest (experimental group)	0.954	38	0.118
Pretest (control group)	0.854	38	0
Posttest (control group)	0.776	38	0

The hypothesis test in this study used the Mann-Whitney test because the data in one of the classes was not normally distributed. The results of the Mann-Whitney test indicated an average conceptual understanding score of 48.82 for the experimental class and 28.18 for the control class. This means that the average conceptual understanding score in the experimental class is higher than in the control class. The Mann-Whitney U value was 330., and the Wilcoxon W value was 1071. When converted to a Z score, the result was -4.151, with an Asymp sig. (2-tailed) value of 0.001. The conclusion derived from the Mann-Whitney U test is that the null hypothesis is accepted because the Asymp sig. (2-tailed) value is less than 0.05, specifically 0.001, indicating a significant difference in the conceptual understanding scores between the experimental and control classes.

Table 7. The result of Mann-Whitney U

Measurement	Value
Mann-Whitney U	330
Wilcoxon W	1071
Z	-4.151
Asymp. Sig. (2-tailed)	0

Subsequently, an N-Gain test was conducted to determine the effectiveness of the applied learning model. The analysis of the average student conceptual understanding results through the N-Gain test can be seen in the table. The table shows that the N-Gain for the experimental class was 0.41, which falls into the medium category, whereas the N-Gain for the control class was 0.21, which falls into the low category. The conclusion drawn is that the cooperative learning model with peer tutoring is effective in enhancing students' conceptual understanding.

5. Discussion of research findings

The study was conducted to determine the impact of the cooperative learning model using the peer tutoring method on high school students' conceptual understanding of sound waves. Analysis of the pre-test and post-test results indicated that the use of the cooperative learning model with peer tutoring positively influenced students' conceptual understanding compared to the conventional learning model. This finding aligns with the results of previous research, which demonstrated that the cooperative learning model using the peer tutoring method effectively enhances students' conceptual understanding test scores (Agustianto, Soeparmi, et al. 2018). This effectiveness can be attributed to the direct involvement of students in the learning process.

During the learning process, students feel more relaxed and can communicate their misunderstandings to the tutor within their group. Groups are formed based on students' proximity to one another, fostering a more comfortable environment for discussion and active participation. Additionally, students are indirectly trained to teach and explain concepts to others. This approach makes learning more engaging and encourages students to seek information independently rather than relying solely on the teacher. The peer tutoring method also improves students' communication skills (Cahyati and Kartika 2019),, who stated that the peer tutoring method actively involves students in the learning process and enhances their communication abilities.

Descriptive analysis results showed that the experimental class had higher conceptual understanding scores compared to the control class. This analysis indicates that the peer tutoring method has a greater impact than the conventional learning model. Subsequent analysis included a normality test, which revealed that the experimental class data were normally distributed, while the control class data were not, necessitating the use of non-parametric statistical tests. The homogeneity test indicated that both classes were homogeneous. The Mann-Whitney U test further supported the hypothesis, showing a significant impact of the cooperative learning model with peer tutoring on students' conceptual understanding (Gustiawan 2021).

The analysis of conceptual understanding showed that both classes experienced improvement, with the experimental class showing higher and more consistent gains across various aspects. The highest score in the experimental class was 88.16% in the interpreting aspect, while the lowest was 42.98% in the comparing aspect. To further validate these findings, an N-Gain test was conducted, showing an N-Gain score of 0.41 (41%) for the experimental class, categorized as medium, and 0.29 (29%) for the control class, categorized as low. These N-Gain results confirm that the cooperative learning model with peer tutoring significantly influences students' conceptual understanding.

6. Conclusion

The conclusion drawn from this study is that the cooperative learning model using the peer tutoring method significantly enhances students' conceptual understanding of sound waves compared to the conventional lecture-based learning model. This is evidenced by a greater increase in scores from the pre-test to the post-test in the experimental class compared to the control class. The experimental class had an average post-test score of 64.04, classified as high, while the control class had an average post-test score of 53.86, classified as moderate.

The use of the cooperative learning model was shown to positively impact students' conceptual understanding, achieving an N-Gain score of 0.41, or 41%, categorized as moderate. The analysis of conceptual understanding revealed that both classes improved, with the experimental class showing higher and more consistent improvements across various aspects. The highest score in the experimental class was 88.16% in the interpreting aspect, while the lowest was 42.98% in the comparing aspect. In contrast, the control class's highest percentage was 75% in the explaining aspect, with the lowest being 42.98% in the predicting or concluding aspect. All aspects of conceptual understanding showed an increase in percentage from the pre-test to the post-test in the experimental class, whereas the control class experienced a decline in the exemplifying aspect.

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