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Diagnosing Students' Concept Understanding Using TGT Cooperative Model on Light Wave Material

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A B S T R A C T

Purpose: Concept understanding is necessary for students to learn physics material. The purpose of this study was to determine the ability of students' concept understanding using TGT type cooperative model in physics material of light wave material.

Methods and Materials: The research method used is qualitative research with a case study to analyze students' concept understanding using the TGT type cooperative model. The research was conducted using qualitative methods with the research subjects being students of class XI IPA B as many as 38 students.

Results: This analysis revealed that the cooperative learning approach proved to be a useful strategy in supporting students' learning process.

Conclusion: Based on the results of the study, it can be concluded that students' understanding of concepts using the TGT type cooperative model in class XI IPA B students at one of the MAs in Yogyakarta in the material of light waves is quite good. This can be seen from their ability to understand the basic concepts of waves, such as frequency, wavelength, and wave speed. However, in some light wave subchapter materials, students have not shown optimal understanding. This is especially true for the concepts of interference and diffraction. The application of the TGT (Teams Games Tournament) cooperative learning model can help improve concept understanding on this difficult material.

Keywords: *Concept understanding, Cooperative Learning Model, TGT (Teams Games Tournament) Cooperative Learning Model, Light waves.*

1. Introduction

Student activeness in the learning process is the main key to achieving lively and quality learning. This is evidenced by the high level of learning success in classes that involve all or most of the students actively, both physically and mentally (Magfira Febriana, 2018). Student learning interest is an important factor in encouraging this activeness. Students who have a high interest in the subject matter will find it easier to achieve optimal learning results, compared to students who have no interest.

Low learning outcomes are not always caused by students' lack of intelligence, but it could be due to their lack of interest in learning. This results in students not being motivated to exert their abilities to the fullest. One of the factors that influence interest in learning is the learning model applied by the teacher. Inappropriate learning models can make it difficult for students to understand the subject matter presented (Zuraini Zaki al Fuad, 2016) Science learning in schools is often dominated by the traditional lecture method, where teachers deliver material directly and students only listen.

Natural Science (IPA) is a compulsory subject at all levels of education, starting from elementary school to college. According to Prihantoro et al (1986) in Trianto (2010), the nature of science is divided into three aspects, namely product, process, and application. As a product, science produces a set of knowledge, concepts, and concept charts. As a process, science uses concepts to study objects of study, discover, and develop science products. Meanwhile, as an application, IPA theories give birth to technology that facilitates human life (Trianto, 2010).

To increase students' activeness and interest in learning, the cooperative learning model is the right choice. This learning model focuses on cooperation between students in achieving learning objectives. Applied through small groups, cooperative learning encourages students to learn and work collaboratively (Abdul Majid, 2017). Then this learning model is interesting and innovative to increase students' interest in learning, this aims to make the subject matter delivered by the teacher can be understood easily and memorable in their memories (Salma & Ayu Reza, 2017). One method that is fun for science students is an experiment (practicum). The experiment chosen is very simple but able to arouse interest in learning and encourage student activeness in learning. An example of a simple experiment conducted by students is identifying the nature of light in light wave material.

Light waves are a natural phenomenon that has fascinated humans since ancient times. From the hues of the rainbow spectrum to light reflecting off the surfaces of objects, an understanding of light waves is essential in physics and many other fields. However, in an educational context, challenges often arise in ensuring proper understanding of this concept by students. To address this, the TGT (Teams Games Tournament) type cooperative model approach emerges as an attractive alternative. (Rofiq & Sari, 2021); and is one example of a learning model that applies simple experiments in its implementation.

The TGT cooperative model is one of the cooperative learning methods that utilizes teamwork in understanding certain concepts. In the context of understanding light waves, the use of this model is interesting because of its ability to build social interaction and collaboration among students. Through discussion (Salma & Ayu Reza, 2017). Suseno (2008) explains that the Teams Games Tournament (TGT) learning model is a group work approach that aims to develop interpersonal cooperation through games that contain competition based on predetermined rules. Trianto (2010) says that TGT was developed by David De Vries and Keath Edward, in which students play with other team members to score additional points for their team. From this explanation, it can be seen that in TGT, teachers must be creative in learning. TGT learning also trains cooperation in groups without eliminating individual responsibility in team discussions. Competitive activities in tournaments also increase students' competitiveness and their concept understanding (Trianto, 2010).

The results of this study are expected to make an important contribution to the development of physics education at the school level. With a better understanding of the effectiveness of the TGT-type cooperative model in the context of light wave material, teachers can design more effective and interesting learning for students. In addition, this study can also serve as a basis for further research in identifying and developing learning approaches that suit the needs of students in understanding complex physics concepts.

In the context of this study, it is important to note that students' concept understanding is not static, but can develop over time and with various appropriate learning approaches. Therefore, the results of this study are not only relevant for the present, but can also provide valuable insights for future curriculum development and learning strategies. By taking into account the various factors that influence student understanding, both individually and in groups, the TGT-

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type cooperative model approach can be one of the effective strategies in improving learning outcomes in light wave physics.

Active and quality learning is essential to help students understand complex concepts in various subjects, including Science. Particularly in science learning about light waves, there is often a challenge to ensure students really understand the concept. Therefore, innovative learning approaches that actively involve students are needed. The active involvement of students in the learning process is the main key to achieving dynamic and quality learning. This is evidenced by the high success rate in classes that involve most or all students actively, both physically and mentally (Magfira Febriana, 2018). Student learning interest is an important factor in encouraging this activeness. Students who have a high interest in the subject matter will find it easier to achieve optimal learning results than students who have no interest.

1.1. • Student Concept Understanding

Concept understanding is one of the important aspects in the teaching and learning process, especially in science learning such as physics. According to Bloom (1956), concept understanding is the ability to capture the understanding, meaning, and significance of a concept that has been taught (Bloom, 1956). Concept understanding is not just remembering formulas or definitions, but also involves mental processes such as organizing, connecting, and interpreting knowledge (Anderson & Krathwohl, 2001). The importance of concept understanding in physics learning has been emphasized by many experts, because the concepts in physics are interrelated with each other (Dahar, 2011).

Some indicators that can be used to measure students' concept understanding include: (1) the ability to translate or restate a concept, (2) the ability to provide examples and non-examples of concepts, (3) the ability to classify certain objects according to the concept, (4) the ability to present concepts in various forms of mathematical representation, and (5) the ability to relate concepts to other concepts or to everyday life (Cruce, 2009). Factors that can affect students' concept understanding include internal factors such as students' interest, motivation, initial ability, and learning style, as well as external factors such as the learning environment, the learning methods used, and the teacher's ability to manage the class (Farida, 2017; Sari & Sutikno, 2010).

To improve students' concept understanding, one alternative that can be done is to apply a cooperative learning model. Cooperative learning model is a learning model that prioritizes cooperation in small groups to achieve learning objectives (Slavin, 2011, 2015).

1.2. • Cooperative Learning Model

The cooperative learning model is a learning model that prioritizes cooperation in small groups to achieve learning objectives (Slavin, 2011). In the cooperative learning model, students are divided into heterogeneous small groups, both in terms of academic ability, gender, race, and socio-economic background. Each group member works together and helps each other to understand the subject matter. Thus, learning objectives can be achieved together by all group members.

The cooperative learning model has several main characteristics, including: (1) students work in small groups, (2) there is positive interdependence among group members, (3) there is face-to-face interaction, (4) there is individual accountability, and (5) there is the use of interpersonal and small group skills (Slavin, 2015). Some of the advantages of cooperative learning models include increasing learning motivation, helping students develop critical thinking skills, practicing social skills, and helping students understand difficult concepts.

There are several types of cooperative learning models, including Student Teams Achievement Divisions (STAD), Jigsaw, Team Games Tournament (TGT), Team Assisted Individualization (TAI), and Cooperative Integrated Reading and Composition (CIRC) (Slavin, 2015). The selection of the right type of cooperative learning model is adjusted to the learning objectives, subject matter, and students' characteristics. The application of cooperative learning models has been widely researched in various subjects, including physics, and proven effective in improving learning outcomes, concept understanding, and student learning activities (Hasibuan et al., 2019; Rofiq & Sari, 2021; Winarni et al., 2018).

The cooperative learning approach provides not only academic but also social benefits for students. Through learning activities in small groups, students are trained to appreciate differences, listen to others' views, and improve interpersonal communication skills. This is important to prepare students for a diverse social life that demands the ability to interact with various individuals from different backgrounds. Thus, cooperative learning methods not only

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make students more active and understand the subject matter better, but also help build attitudes of tolerance, empathy, and cooperation. These positive values will shape students' characters into more holistic individuals who are ready to face future challenges.

1.3. • *TGT (Teams Games Tournament) Cooperative Learning Model*

TGT (Teams Games Tournament) is one type of cooperative learning model developed by Robert Slavin and his colleagues at John Hopkins University (Slavin, 2015). TGT is a learning model that combines group learning activities with instructional games (academic games) and academic tournaments (Slavin, 2011). In the TGT model, students are divided into several heterogeneous small groups. Each group member works together to learn the material provided by the teacher, then they conduct academic games and academic tournaments to score for their respective groups (Slavin, 2015).

The steps of implementing the TGT model according to Slavin (2015) are: (1) forming groups heterogeneously, (2) the teacher delivers the subject matter, (3) group learning, (4) implementation of academic games/academic games, (5) implementation of academic tournaments, and (6) group awards. Some of the advantages of the TGT model include increasing learning motivation, cooperation and interaction between students, and understanding of concepts. In addition, the TGT model also involves fun learning activities (Slavin, 2015). While the shortcomings of the TGT model include requiring a long time, difficult to control students during the game, and requiring considerable costs (Slavin, 2015; Shoimin, 2014).

The application of the TGT model has been widely studied in physics learning and proven effective in improving learning outcomes, concept understanding, and student learning activities (Hasibuan et al., 2019; Rofiq & Sari, 2021; Winarni et al., 2018). In this study, the TGT model was used to diagnose students' concept understanding on light wave material.

1.4. • *Light Waves*

Light waves are one of the important materials in physics learning at the SMA/MA level. Light is a form of electromagnetic wave that can propagate through a medium or without a medium (Giancoli, 2014). Light waves have wave properties such as reflection, refraction, interference, and diffraction (Serway & Jewett, 2018). The light wave material also includes concepts such as light dispersion, the formation of the color spectrum, and the photoelectric effect related to the quantum theory of light (Giancoli, 2014).

Learning the concepts of light waves in depth is very important, as light has many applications in everyday life. For example, light is used in optical equipment such as microscopes, telescopes, cameras, and fiber optic telecommunication devices (Young & Freedman, 2016). In addition, an understanding of light waves is also required in learning other materials such as geometric optics, modern optics, and quantum physics (Giancoli, 2014). However, light waves are often considered difficult by students because they involve abstract concepts and phenomena that cannot be observed directly (Amin et al., 2020; Kadir et al., 2019).

To help students understand the concepts of light waves well, an appropriate learning strategy is needed. One strategy that can be used is to apply cooperative learning models such as Teams Games Tournament (TGT) (Hasibuan et al., 2019; Rofiq & Sari, 2021). The TGT model involves group learning activities, academic games, and academic tournaments that can help students understand light wave concepts in a more fun and interactive way (Slavin, 2015).

2. Methods and Materials

This research is a qualitative research with a case study to analyze the understanding of physics concepts of MA students. Qualitative research is research aimed at describing phenomena, events, attitudes, social activities, perceptions, thoughts of people individually or in groups. Qualitative research is research that produces descriptive data in the form of written, spoken and behavioral words from people who can be observed. This research was conducted in class XI IPA B MA Ali Maksum Krapyak Yogyakarta. The subjects of this research were students of class XI IPA B which amounted to 38 students. The instrument used to evaluate this research, namely description questions with physics material in the physical optics chapter with light waves subchapter.

The data collection technique used is the results of student practice questions, the understanding of concepts analyzed in the study uses indicators of concept understanding according to Pollatsek, namely computational understanding that applies equations in simple calculations. This ability is classified as a low-level thinking ability and functional understanding, namely linking a concept / principle with other concepts / principles, and realizing the process it does.

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This ability is classified as a high-level physics thinking ability.

Data analysis is an effort to decompose a problem or focus of study into parts so that the arrangement and order of the form of something that is decomposed appears clearly visible and easy to digest or capture its meaning (Helaluddin, 2019). Data analysis in qualitative research is carried out during data collection, and after completing data collection. Activities on qualitative data analysis are carried out interactively and take place continuously until completion.

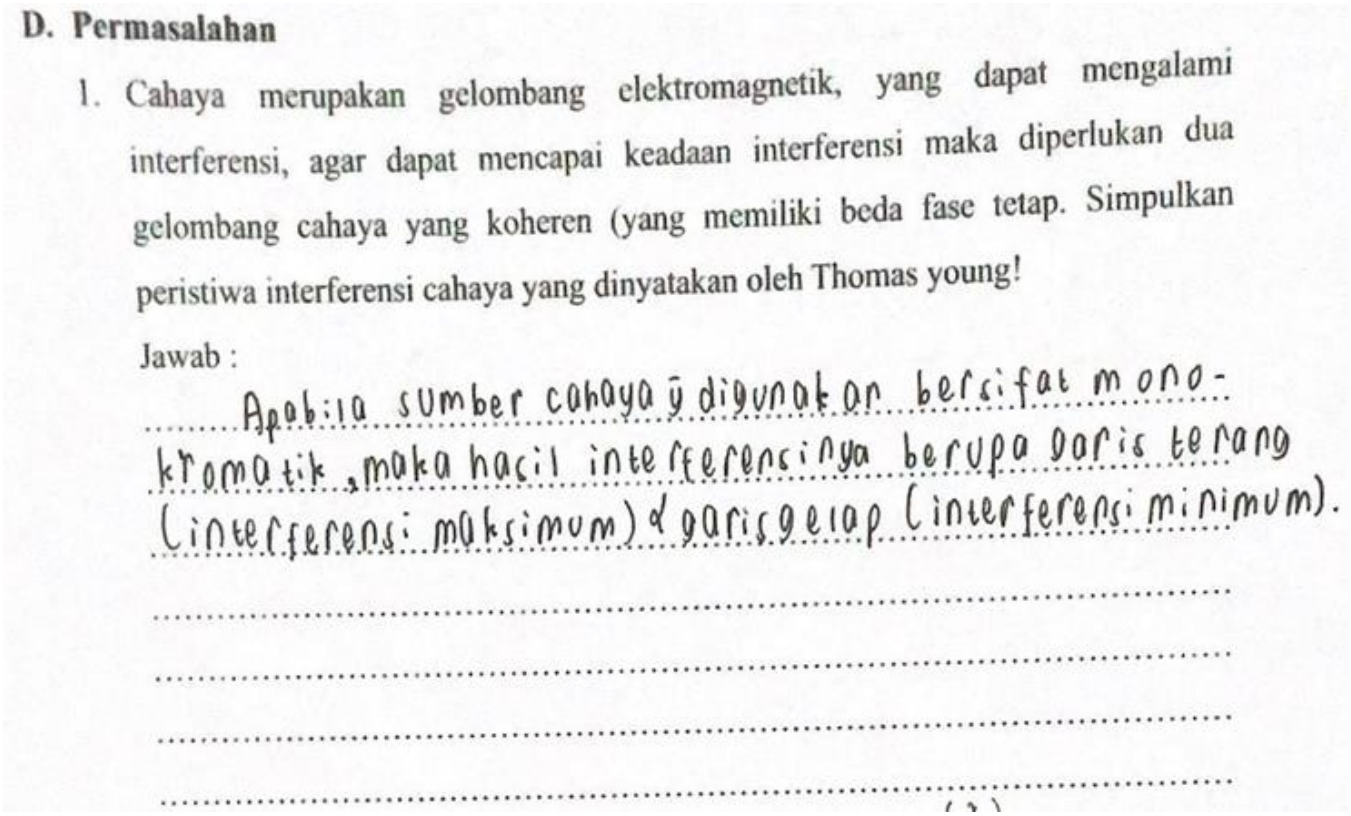
The data analysis technique in this study is described as several stages in analyzing interactive model data, namely data reduction (data reduction), data display (data presentation), conclusion drawing / verification (conclusion drawing). Data reduction is a form of analysis to sharpen, select, focus, discard and organize data towards drawing conclusions (Helaluddin, 2019). In qualitative research, data presentation can be done in the form of brief descriptions, charts, relationships between categories, flowcharts and the like. By presenting the data, it will be easier to understand what is happening, continue further work based on what has been understood (Putra, 2012). Decision making and verification. This method aims to present a systematic, factual and accurate description of the facts and relationships of the phenomena under study, to test their truth and suitability (Putra, 2012).

3. Findings and Results

The understanding of physics concepts of students in class XI IPA B MA Ali Maksum Krapyak Yogyakarta on light wave material is quite good. This can be seen from their ability to understand the basic concepts of waves, such as frequency, wavelength, and wave speed. However, in some light wave subchapter materials, students have not shown optimal understanding. This is especially true for the concepts of interference and diffraction. The following is the observation data, namely student answers and their analysis:

Figure 1

Results of Posttest Answer Number 1


D. Permasalahan

1. Cahaya merupakan gelombang elektromagnetik, yang dapat mengalami interferensi, agar dapat mencapai keadaan interferensi maka diperlukan dua gelombang cahaya yang koheren (yang memiliki beda fase tetap. Simpulkan peristiwa interferensi cahaya yang dinyatakan oleh Thomas young!

Jawab :

Apabila sumber cahaya yg digunakan bersifat monokromatik, maka hasil interferensinya berupa garis terang (interferensi maksimum) & garis gelap (interferensi minimum).

From the results of the student's answer that the answer falls into the correct category. Because in the case of a monochromatic light source, all light waves have the same wavelength and frequency. This means that all light waves have the same phase. When two monochromatic light waves meet, they will always experience constructive interference

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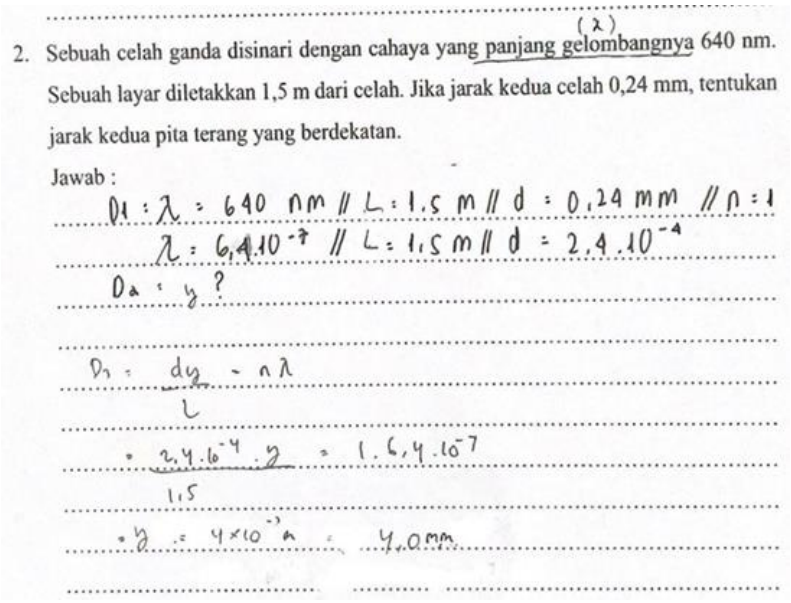
at some points and destructive interference at other points. This results in an interference pattern consisting of a bright line and a dark line. Thus, it can be concluded that the student's answer is able to fulfill all indicators of concept understanding ability.

Figure 2

Results of Posttest Answer Number 2



From the results of student answers that the answers fall into the correct category because the calculations are correct students follow the example problems contained in the LKPD and the results are correct. Therefore, in question number 2 shows that students are able to fulfill all indicators of concept understanding ability.

Figure 3

Results of Posttest Answer Number 3

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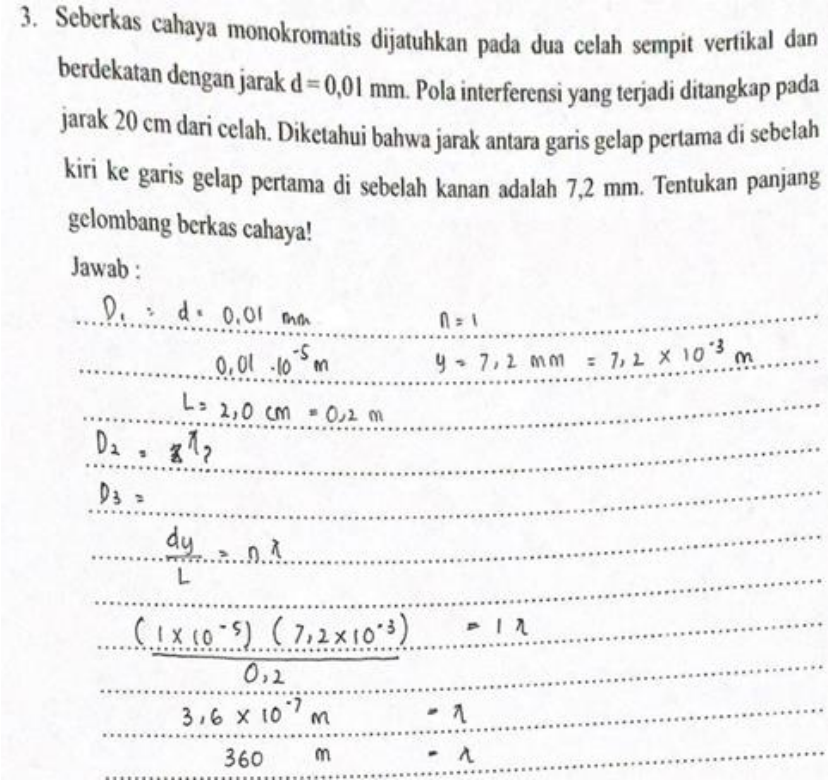
3. Seberkas cahaya monokromatis dijatuhkan pada dua celah sempit vertikal dan berdekatan dengan jarak d = 0,01 mm. Pola interferensi yang terjadi ditangkap pada jarak 20 cm dari celah. Diketahui bahwa jarak antara garis gelap pertama di sebelah kiri ke garis gelap pertama di sebelah kanan adalah 7,2 mm. Tentukan panjang gelombang berkas cahaya!

Jawab :

D_1 : d = 0,01 mm n = 1

$0,01 \cdot 10^{-5}$ m $y = 7,2$ mm $= 7,2 \times 10^{-3}$ m

L = 2,0 cm = 0,2 m

$D_2 = \lambda ?$

$D_3 =$

$\frac{dy}{L} = n\lambda$

$\frac{(1 \times 10^{-5})(7,2 \times 10^{-3})}{0,2} = 1\lambda$

$3,6 \times 10^{-7}$ m $= \lambda$

360 m $= \lambda$

From the results of student answers that the answers fall into the correct category because the calculations are correct students follow the example problems contained in the LKPD and the results are correct. Thus, in question number shows that students are able to fulfill all indicators of concept understanding ability.

Based on the response data of students' post-test answers, the following is a descriptive analysis by selecting the highest student answers:

1. For question number 1 on the concept of light interference and the explanation of Huygens' principle, most students' answers fell into the correct/approximate correct category with a total of 5 groups. Only 1 group gave almost correct answers, and no group gave wrong answers.
2. For question number 2, which related to the calculation of the bright band distance in double slit interference, all groups (6 groups) gave correct/approximate correct answers. No answers were categorized as almost correct or incorrect.
3. For question 3, which also involved calculations related to wavelength in double-slit interference, all groups (6 groups) gave correct/approximate correct answers. No answers were categorized as almost correct or incorrect.

From the analysis above, it can be concluded that the highest number of students' answers were correct/approximate correct for questions 2 and 3 relating to the calculation of double slit interference. All groups (6 groups) managed to answer correctly/nearly correctly on both questions.

This shows that most students have understood the concepts and calculations related to double slit interference well. However, for question number 1 which relates to the concept of light interference in general, there is still 1 group that gives almost correct answers, so it is necessary to strengthen understanding of the concept in that section.

4. Discussion and Conclusion

The application of cooperative learning model type TGT (Teams Games Tournament) can help improve concept understanding on this difficult material. In TGT, students are divided into small groups to learn together, followed by academic games in the form of intergroup tournaments. With group learning and intergroup competition, students become more motivated to understand concepts well in order to collect the best score for their group.

Many students pay attention but do not know the concepts emphasized by the teacher so that students will have difficulty in mastering the material and also difficulty in

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remembering the material that has been delivered by the teacher. Through TGT, students can discuss and explain concepts to their groupmates, so that understanding becomes deeper.

In understanding the concept of students at MA Ali Maksum is not assisted by a package book because at MA Ali Maksum all students are not required to bring a package book during learning, but with material delivered orally or in writing by the teacher. During the learning process, researchers observed students in class XI IPA B that each student has different concept understanding abilities, depending on the individual. There are some learners who can understand concepts quickly, while others need help. There are also those who need to be motivated first, and there are those who have difficulty understanding. Through group work in the TGT cooperative learning model, students who have more ability can help their groupmates who are having difficulties. In addition, tournament competition provides extra motivation for all students to understand the concepts well. Some studies also found that the learning process using cooperative model with TGT approach is effective in improving students' concept understanding (Abdullah & Shariff, 2008; Bilgin, 2006).

The successful application of the TGT type cooperative learning model in improving students' concept understanding on light waves is influenced by several factors. First, TGT emphasizes cooperation in small groups. Through discussion and mutual help, students can clarify their understanding and fill in each other's knowledge gaps. This interaction helps students build a deeper and more thorough understanding of the concepts being studied.

Secondly, the game and tournament components in TGT create a fun and healthy competitive learning environment. The existence of tournaments motivates students to understand concepts well in order to collect the maximum score for their group. However, this competition is conducted in a spirit of togetherness, as the group score is an accumulation of individual scores. This encourages each member to help each other and ensure good understanding among all group members.

Third, the role of the teacher in managing learning with the TGT model is very important. Teachers must be able to create a conducive learning atmosphere, provide appropriate guidance, and design activities and tournaments that are interesting for students. With good management, students will be more involved and motivated in the learning process, so that their concept understanding will be maximized.

However, it should be noted that the successful application of the TGT model also depends on the characteristics of the students and the material being taught. For the abstract nature of light waves, the TGT model proved effective in helping students visualize and understand the concepts. However, for different materials, it may require modification or combination with other approaches in order to achieve optimal results.

To obtain data on the ability to understand the concept of students, researchers looked at the results of students' answers in completing test questions on light wave material in the form of descriptions that are in accordance with the indicators of understanding the concept of physics. The test questions consisted of 3 questions then the students worked in groups with a note that each individual had to take an active role in the process, and then the researchers corrected the students' work from the tests that had been given. The application of TGT requires each group member to understand the concept well in order to contribute optimally in working on group test questions and tournaments.

In research conducted by Augustina (2020) shows that the effect of the TGT type cooperative learning model on the ability to understand the concepts of students in class X physics learning at SMK PGRI 2 Palembang there is a difference with a good category and must be maintained)Agustina, 2020(. In line with this, based on research conducted by Fitriyane et al (2018), it shows that TGT type cooperative learning can improve students' concept understanding. This TGT type cooperative model can provide implications for teachers as an alternative choice in improving students' concept understanding (Fitriyane, 2018).

The cooperative learning approach is proven to be a useful strategy in supporting students' learning process. For students who are actively involved in cooperative learning activities and group assignments, significant progress can be observed in the change of their conceptions, where increased understanding of concepts and a higher level of interconnectedness between concepts, mainly occurs because learners optimize cooperative learning. Activities such as role-playing, group projects, and discussions are reflections of this learning method, one of which uses learning models in the Teams Games Tournament approach (Agustina, 2020; Fitriyane, 2018; Salma & Ayu Reza, 2017; Zuraini Zaki al Fuad, 2016).

Based on the research that has been conducted, it can be concluded that the understanding of students' learning

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concepts using the TGT type cooperative learning model can be carried out well. This can be explained as follows:

The researcher managed to collect data on students' ability to master the understanding of concepts using observation methods, and tests. Students' concept understanding of light wave material in class XI IPA B MA Ali Maksum Krapyak Yogyakarta has shown adequate results by using the Teams Games Tournament (TGT) type cooperative learning model. Students seemed to master the basic concepts of waves such as frequency, wavelength, and wave speed well. However, for the concepts of interference and diffraction, there are still some students who have not achieved optimal understanding.

The implementation of the TGT type cooperative learning model proved to be effective in helping improve students' understanding of more complex materials, such as interference and diffraction. Through group discussion activities, educational games, and intergroup tournaments, students become more motivated to understand the material better in order to achieve the highest score for their group.

From the analysis of students' posttest answers, most of them managed to answer correctly the questions related to the calculation of double-slit interference. However, on the questions that tested the understanding of the concept of light interference in general, there was still one group whose answers were almost correct, indicating that strengthening of concept understanding was still needed in that section.

This research proves that the TGT type cooperative learning model is effective in improving students' concept understanding on light wave material. The cooperative approach in learning proved to be a very useful strategy in supporting students' learning process.

Teachers can utilize the Teams Games Tournament (TGT) cooperative learning model as an alternative strategy to improve students' concept understanding, especially on challenging topics such as interference and diffraction of light waves. In implementing the TGT model, it is important for teachers to ensure every student actively participates in group discussions and the learning process. This can be achieved by providing tasks or questions that must be answered individually before being discussed in groups.

Teachers also need to strengthen the understanding of concepts in the material that students have not mastered well, such as the concept of light interference in general. This reinforcement can be done through additional explanation, class discussion, or using more interesting learning media. To increase student motivation and engagement, teachers can develop variations in the academic games and tournaments used in the TGT model. This approach can make the learning process more interesting and fun for students. Schools can also support the implementation of the TGT cooperative learning model by providing adequate facilities, such as supportive classrooms and appropriate learning media. Further research can be conducted to explore the application of the TGT model on other physics materials or at different educational levels, so that a more comprehensive picture of the effectiveness of this learning model can be obtained.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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