An analysis of students’ conceptual understanding using STEM approach educational videos

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Abstract. This study aims to determine and analyze the conceptual understanding of students who are taught using STEM approach learning videos on sound wave material. This research is a qualitative descriptive study. The research subjects consisted of 19 students of Grade XI of MAN 2 Palu Model in the even semester of the academic year of 2019/2020. The instruments used were a multiple choice test accompanied by a Certain of Response Index (CRI) which was given before and after being taught with STEM approach educational videos, as well as interviews. Respondents included those of high, medium, and low categories proficient students and were willing to do an interview test. The results of this study indicate that the comprehension of the material concept of students before being taught using the educational video integrated with the STEM approach can be categorized as low, and after given the educational video with the STEM approach, the students’ understanding of the concept increases. Therefore, educators can apply STEM approach learning videos in the learning process. For further researchers, this study can provide an overview of the conceptual understanding of students being taught with STEM approached learning videos. Hence, researchers can develop research using other learning media or in a broader cognitive domain.

1. Introduction
In today's 21st century, science and technology continue to develop rapidly. The challenges faced by each individual to survive are also getting tougher, both on an individual and global level. Competition already covers the global world, and therefore it is necessary to develop a way or strategy to sustain life in order to survive in this fast-paced era. Strategies which can be done are mastering science and technology, as well as increasing creativity, which are the determining factors for progress [1].

In Indonesia, the 2013 curriculum which has been implemented is expected to guide students to think critically, creatively and be able to solve problems. The 2013 curriculum aims to produce students who can think critically and play an active role in dealing with a problem in the era of industrial globalization 4.0, which results in that teachers must provide a meaningful learning process according to their respective creativity [2,3].

Therefore, in order to face the 4.0 industrial revolution in accordance with the objectives of the 2013 curriculum, the Science Technology Engineering and Mathematics (STEM) approach can be used in the learning process [4]. STEM-based learning refers to the learning which combines science, technology, engineering, and mathematics within the learning process. The purpose of STEM is to
encourage students to develop scientific and technological literacy which has an impact on the students' skills of reading, writing, observing, and doing science, and is able to develop the competencies they have to be applied in dealing with problems in everyday life related to the field of STEM science [5]. This is in line with the demands of 21st century education, as with the STEM approach in the learning process, students are expected to better understand the concepts to be conveyed and apply them in everyday life [6].

Physics is one of the branch subjects of science which is very closely related to everyday life. Assisting students' understanding to master the concepts and their relationships in order to solve problems in everyday life is the goal of learning physics [7]. Students can achieve academic success in studying physics if they are able to understand the taught physics concepts and are able to apply them in the physics problem solving activities [8]. By using the STEM approach, students are expected to be able to understand the contents distributed.

Physics learning media refers to a tool which can help students understand a concept that is needed in the physics learning process [9]. One of the media which utilizes the Internet and can increase the effectiveness of learning, as an alternative, is educational video, which includes audio and visual elements [10].

Wave sound is one of the topics that students must master well in learning physics, however, in the implementation of the physics learning itself, there are still misconceptions that occur in students. Sound waves are a type of transverse waves [11]. This concept error can occur as students may experience difficulties in learning. There are several factors that affect students' learning difficulties, namely: 1) students are still uninterested in sound lessons, 2) students still have difficulty in working on sound wave exercises, 3) students lack attention, 4) students lack of effort in learning [12].

There are several advantages of video, namely: 1) video can display motion, 2) video can show the process of science experiments. 3) Real-life experiences, videos can enable students to be able to observe events that cannot be seen directly because they are dangerous or long distances, 4) Repetition, which can be repeated so that they can understand the message easily [10]. The benefits of STEM learning are that it can improve students' problem solving abilities, think logically, be innovative, be independent, and have technological literacy [5].

In previous research, STEM learning can improve students' understanding of concepts [13], train students in critical and creative thinking [14,15], and develop students' scientific attitudes. The difference between this study and previous research lies in the application of the STEM approach in a learning video on sound waves. Based on the explanation above, the researcher decided to conduct a study to analyze the conceptual understanding of students who were taught with STEM approach learning videos on the topic of sound waves. The purpose of this study was to determine and analyze the conceptual understanding of students who were taught using STEM-approached learning videos on the topic of sound waves.

2. Research Methodology

The type of research used in this research is descriptive qualitative. This research was conducted in MAN 2 Model Palu. The study was conducted during the even semester in Grade XI MAN 2 Palu Model, in the 2019/2020 academic year. The subjects of this study consisted of 19 students of Grade XI Science 1. This study utilizes a conceptual understanding test in the form of multiple choices accompanied by a CRI (Certainty of Response Index) scale. Referring to the test results, respondents are selected based on high, medium, and low categories. Concept understanding tests and interviews were conducted twice, namely the initial test and after being given a learning video integrated with the STEM approach.

The CRI scale used refers to the scale compiled by Salem [16]. The CRI scale can be seen in Table 1.
Table 1. CRI Scale.

| CRI | Criteria |
|-----|----------|
| 0   | Totally guessing answer: if students guessed 100% of the test |
| 1   | Almost guessing: if students guessed 75% - 99% of the test |
| 2   | Unsure: if students guessed 50% - 74% of the test |
| 3   | Sure: if students guessed 25% - 49% of the test |
| 4   | Almost certain: if students guessed 1% - 24% of the test |
| 5   | Certain: if students answered without any guesses (0%) |

Next, the analysis of students' answers is carried out to differentiate between students who understand the concept, those who misunderstand, and those who do not understand the concept. To differentiate students' conceptual understandings, a table is developed for determining the conceptual understandings of students based on the CRI index, which was carried out by Hasan, Bagayako, & Kelley [16].

Table 2. Determining Student Conceptual Understandings Based On The CRI Index

| Options | Low CRI (<2.5) | High CRI (>2.5) |
|---------|---------------|-----------------|
| Correct | The answer is correct, but the CRI is low. It means that the student does not fully understand the concept. | The answer is correct, and the CRI is low. It means that the student can fully understand the concept. |
| Incorrect | The answer is incorrect, and the CRI is high. It means that the student does not understand the concept. | The answer is correct, but the CRI is high. It means that the student misunderstands the concept. |

To calculate in which category of understanding concepts, misconceptions, and not understanding concepts the students belong in, the following equation is used:

\[ P = \frac{f}{N} \times 100\% \]  \( (1) \)

\( P = \) Percentage of question items answered by students

\( f = \) Number of question items answered by students

\( N = \) Number of students

Then, the percentage level of students' understanding of the concept of sound waves to differentiate between high, medium and low categories of students is determined. The percentage level of the students' understanding of the concept was adopted by Sari, et al [17].

Table 3. Conceptual Understanding Level in Percentage

| No. | Percentages | Category |
|-----|-------------|----------|
| 1   | 0% ≤ x ≤ 30% | Low      |
| 2   | 30% < x ≤ 60% | Moderate |
| 3   | 60% < x ≤ 100% | High     |

3. Findings And Discussion

3.1. Research Findings

After distributing the conceptual understanding test, the results of the data analysis on students' understanding of the concept of sound waves are obtained in Table 4.
Table 4. The Analysis of The Conceptual Understanding Before And After The Implementation Of Stem Approach Educational Videos.

| Category | Before the Use of STEM Approach Educational Video | After the Use Of STEM Approach Educational Video |
|----------|--------------------------------------------------|--------------------------------------------------|
| P (%)    | 22.27                                            | 51.01                                            |
| TP (%)   | 36.03                                            | 23.89                                            |
| M (%)    | 41.70                                            | 25.10                                            |

Table 4 shows that students' understanding of concepts has increased by 28.74%, while for the percentage of students who do not understand concepts and those who experience misconceptions have a decrease of 12.14% and 16.60% respectively. However, the decrease in not understanding the concept is still low. The results of the research on the student conceptual understanding were analyzed using CRI. The results obtained for each indicator of student conceptual understanding are displayed in Table 5.

Table 5. Percentage of Student Conceptual Understanding before Given the Educational Video

| Conceptual Understanding Indicators | Student Conceptual Understanding for Each Category |
|------------------------------------|--------------------------------------------------|
|                                    | P%       | TP%     | M%     |
| Translation (1,2,3,4,5)            | 31.58    | 31.58   | 36.84  |
| Interpretation (6,7,8,9,10)        | 14.74    | 37.89   | 47.37  |
| Extrapolation (11,12,13)           | 19.30    | 40.35   | 40.35  |

Referring to the results displayed in Table 5, it can be seen that students' conceptual understanding before being given an educational video on the translation indicators for the categories of understanding the concepts, not understanding the concepts, and misconceptions were respectively 31.58%, 31.58%, and 36.84%. The interpretation indicators for the categories of understanding the concept, not understanding the concept, and misconceptions were respectively 14.74%, 37.89%, and 47.37%. Meanwhile, the extrapolation indicators for the concept understanding, concept understanding, and misconception categories were 19.30%, 40.35%, and 40.35%, respectively.

Table 6. Percentages of Student Conceptual Understanding after Using the Educational Videos

| Conceptual Understanding Indicators | Student Conceptual Understanding for Each Category |
|------------------------------------|--------------------------------------------------|
|                                    | P%       | TP%     | M%     |
| Translation (1,2,3,4,5)            | 62.1     | 16.84   | 21.05  |
| Interpretation (6,7,8,9,10)        | 47.37    | 26.32   | 26.32  |
| Extrapolation (11,12,13)           | 38.60    | 31.58   | 29.82  |

Based on Table 6, it is seen that students' conceptual understanding after being given a learning video on the translation indicators for the categories of understanding the concepts, not understanding the concepts, and misconceptions were 62.11%, 16.84%, and 21.05%, respectively. The interpretation indicators for the categories of understanding the concept, not understanding the concept, and misconceptions were respectively 47.37%, 26.32% and 26.32%. Meanwhile, the extrapolation indicators for the concept understanding, concept understanding, and misconception categories were respectively 38.60%, 31.58%, and 29.82%.

3.2. Discussion

The conceptual understanding in this study is analyzed using several conceptual understanding indicators, namely translation, interpretation, and extrapolation. The following are the results of students' understanding of concepts based on the aforementioned indicators of conceptual understanding.
The items for the translation indicators are question numbers 1, 2, 3, 4, and 5. Students' understanding of the concepts before being given the educational video with STEM approach is classified as moderate, whereas after being given a learning video with STEM approach, students' understanding of concepts becomes high. This is due to the fact that most students have been able to translate the relationships described in the form of tables, pictures, and mathematical equations into verbal language and vice versa. In this indicator, students who experience misconceptions and do not understand the concept assume that echo is a reflected sound that is heard after the original sound and is exactly the same. The items for the interpretation indicators are question items numbers 6, 7, 8, 9, and 10. Students' understanding of the concepts before being given a learning video with the STEM approach is classified as low. After giving a learning video with the STEM approach, the students' understanding of the concept was classified as moderate. This is due to the fact that the students are unable to clearly understand and interpret the data in the form of tables and figures. In one of the question items of the interpretation indicator, students who experienced misconceptions assumed that based on this data, the greater the frequency of the sound of the ambulance sirens, the smaller the frequency that motorcyclists could hear. Meanwhile, after being given a learning video with a STEM approach, the students assumed that the frequency of the sounds made by an ambulance was almost the same as the frequency heard by motorcyclists.

Meanwhile, the extrapolation indicators consisted of questions numbers 11, 12, and 13. Understanding the concept of students before being given a learning video with a STEM approach is classified as low. After being given a learning video with a STEM approach, the students' conceptual understanding was still low. This is due to the fact that on this indicator, students have not been able to predict and assume the consequences of an action, as well as the fact that they are not able to draw conclusions effectively. In the extrapolation exercises, students' conceptual understanding was categorised in the low category. In question number 11, students who experienced misconceptions assumed that when the sound frequency was lowered, the wavelength was smaller than the frequency and the sound sounded low. The results of a research conducted by Susanti [18] indicate that 33.87% of students experience a misconception by assuming that when the frequency is raised, the wavelength is elongated and the wave speed is constant.

In this study, it is known that students' understanding of the concept increased before and after given the educational video integrated with the STEM approach. This is in accordance with the study conducted by Rivai [13], which stated that there is an effect of students' mastery of concepts on the topic of dynamic fluid before and after being given a treatment in the form of problem-based STEM learning, with an increase in the scores of students' concept mastery in the pretest compared to the post test. According to a research carried out by Istiqomah [19], students' conceptual understanding when using video playback as the media is better than using conventional learning models. Her research was based on the analysis of N-Gain data between the controlled class and the experimental class. The results of this study indicate that the indicator of conceptual understanding of extrapolation has a higher level when compared to the indicators of interpretation and translation. If sorted from the highest level to the lowest levels, then extrapolation comes first, followed by interpretation, and translation is last. This is in line with Bloom's theory [20] which states that extrapolation has a higher level than interpretation or translation.

4. Conclusion
The conclusion drawn from this study is that the conceptual understanding of MAN 2 Palu Model students after being taught using an educational video integrated with the STEM approach can be categorized as moderate. Students' understanding of the concepts before being taught using an educational video integrated with the STEM approach was 22.27%, whereas after being given the treatment, their conceptual understanding scores increased up to 51.01%.
In the translational indicator, students assumed that echo refers to a reflected sound which is heard twice, or a sound that is heard after the original sound. They also thought that the sound source that approaches the listener or vice versa is (-) and the sound source or listener is away from the value (+), one wavelength consists of one belly and two knots. In the interpretation indicator, students assumed that the greater the sound frequency of the ambulance, the smaller the frequency that motorcyclists can hear, while in the extrapolation indicator students assumed that when the amplitude is increased, the sound is higher.

Based on the results of this study, it can be used as a consideration in implementing STEM-based learning and using the indicators of conceptual understanding as stated by Bloom. As a result, it is hoped to improve and measure the level of understanding of students' concepts. This study still has many limitations, both in terms of materials and research methodology, thus, it is hoped that future research can expand the materials, the subjects and the setting of research, as well as modifying the methodology used.

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