P-ISSN: 1693-1246
E-ISSN: 2355-3812
June 2024

Jurnal Pendidikan Fisika Indonesia 20 (1) (2024) 38-51
DOI: 10.15294/jpfi.v20i1.46900

http://journal.unnes.ac.id/nju/index.php/jpfi

The Conceptual Knowledge Test to Measure The Physics Concepts Mastery of Biology Students on Waves Topic

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Received: 12 February 2024. Accepted: 02 May 2024. Published: 25 June 2024

Abstract

Waves is one of the Physics materials that must be mastered and understood. Students need help describing the mechanism of wave movement, so it is necessary to develop a test instrument tailored to the scientific field of Biology. Therefore, the study aimed to develop a Wave conceptual knowledge test instrument that can be used to train and measure the mastery of Physics concepts of the Wave topic of Biology Department students that meet the instrument's feasibility, including content validity, reliability, and difficulty level. This research uses the 4D development model (Four-D models), which consists of four stages: Define, Design, Development, and Disseminate. Instruments-based feasibility is based on content validity, test reliability, and difficulty level. Based on the study results, the instruments developed were based on indicators of achievement of Physics competencies for Biology Department students. The content was adjusted to the field of Biology, namely the concept of waves in the human and animal hearing system. The test instrument met the criteria, namely content validity, test reliability, and difficulty level, so this instrument can be used to train and measure the physics concept mastery of Biology students. The wave topic adapted to the scientific field of Biology can help Biology students understand the wave concepts correctly.

Keywords: physics concept; waves topic; physics for biology; knowledge test

INTRODUCTION

Waves concepts present a fascinating array of physical phenomena (Anwar, Rusdiana, Kaniawati, & Viridi, 2017; Szybka & Cieślik, 2019). The application of wave concepts can be observed in other fields of science, such as engineering (e.g., civil engineering, electronics), aeronautics, geosciences, acoustics, etc. (Harefa, 2019). This demonstrates that a profound comprehension of wave physics is required.

The concept of waves is evident in many events, whether conscious or unconscious (Hermanto, Nurhayati, Tahir, & Yunus, 2023; Yana, Antasari, & Kurniawan, 2020). Waves represent a fundamental aspect of physics that requires thorough comprehension (Jumadin, Hidayat, & Sutopo. 2017; Nabilah, 2021). Understanding wave concepts, including frequency, wavelength, amplitude, superposition, and others, is essential for studying advanced physics such as sound waves. Studying advanced physics fields such as sound waves, light, electricity, magnetism, and quantum mechanics requires mastering the concept of waves. This enables individuals to apply the concepts to solve complex problems. In this case, the ability to comprehend the concept is not limited to identifying it; it must also encompass the ability to connect and relate the concept to other concepts (Adhani & Rupa, 2013).

The study of waves is a fundamental topic in physics, encompassing many concepts students must grasp. Physics material is not solely taught to students enrolled in the Physics Department; it is also imparted to students of the Chemistry and Biology Departments, serving as a foundation for studying advanced science. Students in physics, chemistry, and biology are encountering many difficulties, particularly in the context of wave material.

Indeed, the capacity to comprehend the concept of waves among physics students remains relatively limited. This is evidenced by the research results by Kameo, Handayanto, & Taufiq, 2020), which state that first-year students in even semesters of physics study programs still tend to experience low concept understanding. Consequently, when concept mapping experiments are carried out, most students experience errors in concept processing because their concepts are low. Furthermore, other relevant research conducted by Yana et al (2020) also revealed that students' concept understanding remained inadequate. Students tend to memorize formulas and only receive information from lecturers without understanding the concepts that must be mastered.

The ability of students to comprehend the concept of waves is limited due to the lack of concrete learning materials and the limited availability of instruments that can effectively train students in conceptual understanding. These challenges have led lecturers to rarely incorporate or administer concept-based questions, contributing to the deficiency of student proficiency in solving physics problems posed by lecturers (Sumanik, NurvitasarI, & Siregar, 2021; Widiyanto, Sujarwanto, & Prihaningtiyas, 2018). Other factors, such as the exposure to wave physics concepts, are still abstract, as is the low ability of students to model the problem of physical symptoms mathematically (Raimah, 2021; Widodo, Sari, Suyanto, Martini, & Inzanah, 2020). One of the challenges students face in describing physics problems mathematically is the difficulty in comprehending the relationship between variables in mathematical equations and the difficulty in visualizing the relationship between variables in these equations in a graph (Alethea, Sarwi, & Suharto, 2018; Nurdiansah, Islami, & Nana, 2020). These factors have further implications for the low understanding of the physical meaning of phenomena that occur, especially in wave material.

Another finding is that biology students' mastery of physics concepts is lower than that of students majoring in physics. The cause of this low learning outcome can be analyzed from the lecture process and teaching materials used by lecturers in teaching physics concepts to biology students. Physics material delivered by lecturers during lectures is still dominant in pure physics concepts without any understanding of the field of biology. Similarly, the content of physics teaching materials remains general and lacks a clear link to the field of biology (Damayanti, Perdana, & Sukarmin. 2016). Furthermore, test instruments commonly used as training media in physics problems lack a clear association with problems in biology.

One strategy for enhancing the ability of biology students to comprehend the principles of physics is to develop interdisciplinary physics-integrated teaching materials (Toto & Yulisma, 2017) and compile conceptual knowledge-based physics test instruments that meet the standards of high-quality test instruments (Aisyah & Sucahyo, 2022; Hermanto et al., 2023) that are aligned with biological concepts. This represents an endeavor to achieve interdisciplinary literacy (Capraro et al., 2013). A test instrument is considered good quality and suitable for use if it fulfills the following criteria: substance, construction, and language requirements; evidence of validity; and reliability (Prabowo, Kusdinar, & Rahmawati, 2018).

There is a paucity of conceptual knowledge-based test instruments on wave material associated with the scientific field of biology. The available test instruments on waves are still general and too dominant in the physics concept. Consequently, the existing test instruments do not fulfill the criteria of a good test instrument. Therefore, it is necessary to develop conceptual knowledge-based test instruments with interdisciplinary content so lecturers can use them (Rogers, 2021). This is expected to overcome lecturers' difficulties in obtaining appropriate student assessment results (Retnawati, Hadi, & Nugraha, 2016). This research aims to develop a conceptual knowledge test instrument that can be used to train and measure students' mastery of physics concepts by majoring in biology, especially on the topic of waves. The instrument developed must fulfill feasibility testing, including content validity, reliability, and difficulty level.

METHOD

This research employs the Research and Development (R&D) methodology to produce a test instrument based on conceptual knowledge indicators on waves. The research subjects for instrument testing were Biology Department students in the even semester, comprising 52 students divided into two classes. The selection of research subjects employed a random sampling technique. This research employs the 4D development model (Four-D models) developed by Thiagarajan (1974). This model is arranged sequentially and programmed so that the sequence of activities is systematized, comprising four stages: Define, Design, Development, and Disseminate. In this study, the processing and reporting of research data only reached the Development stage, as the data at the Dissemination stage were still being processed.

The test instrument was developed based on the conceptual knowledge dimension of Bloom's Revised Taxonomy, with indicators including 1) Knowledge of classification and categories, 2) Knowledge of principles and generalizations, 3) Knowledge of theories, models, and structures (Tanjung, Abubakar, Wulandari, & Lubis, 2020; Tanjung & Bakar, 2019). The stages in the process of developing a conceptual knowledge test instrument on the topic of waves are presented in Figure 1.

Preparing test instrument products commences with the definition stage, namely the conduct of needs analysis and student analysis. Literature reviews and previous research studies assist these analysis activities. Literature reviews and previous research were undertaken to identify various sources of information relevant to the development of test instruments. In addition, a survey of the theoretical basis of waves that can be related to the scientific field of biology was carried out so that the formulation of the compiled questions can be understood and applied to biology students.

The design stage comprises the preparation of test specifications (test references) and formats presented in the form of a test instrument lattice, as well as the design of test instruments designated as Prototype 1. Furthermore, at the development stage, content and construct validation tests were conducted by expert validators, and product revisions were carried out. The revised instrument product (Prototype 2) was tested on research subjects to determine its feasibility criteria, including item validity, reliability, differentiating power, and difficulty level. The research subjects were 52 students divided into two classes, selected using simple random sampling.

In the final stage, namely dissemination, the final product that has undergone the instrument's feasibility test is disseminated and employed in Basic Physics or General Physics courses as an assessment tool for the mastery of the Wave concept, particularly for students in the Biology Department. After the learning process, an assessment will be conducted to determine the efficacy of the instrument in achieving its intended learning objectives (Tanjung & Nasution, 2022).

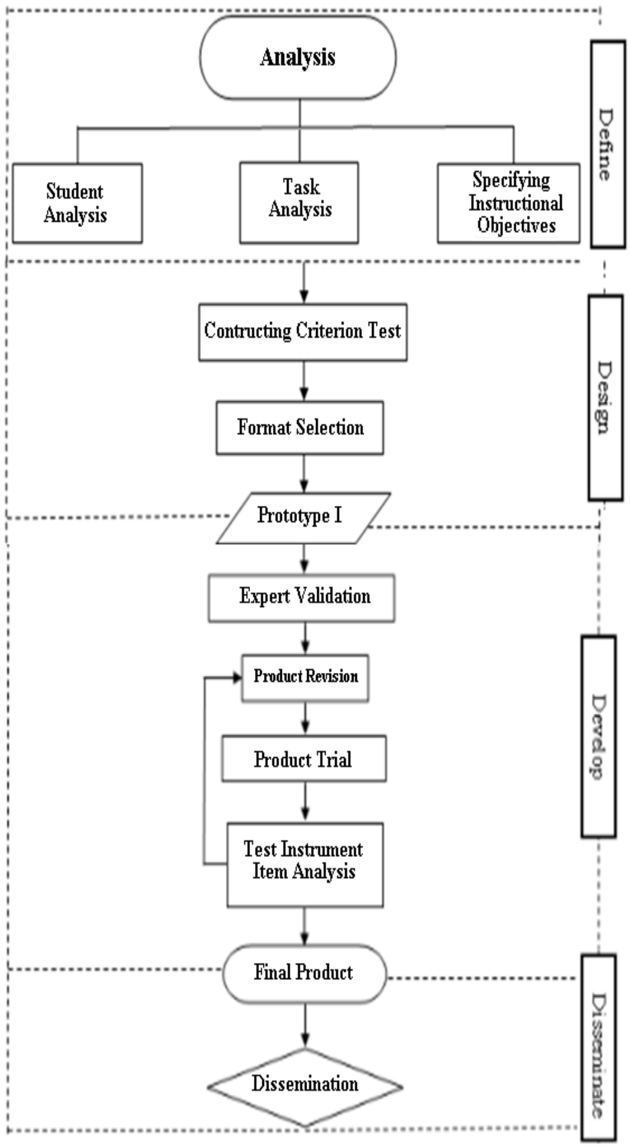


Figure 1. Phases of the Test Instrument Development Process

The data presented in this study were derived from the development stage. These include data on the results of content validity testing by expert validators and data on the results of instrument testing, namely reliability and difficulty level data. The data analysis technique is described in the following section.

<u>Content Validity</u>

The data obtained on content validity results from an assessment conducted by two validators, each with expertise in the assessment and evaluation of learning and material experts. The assessment was conducted using a Likert scale score. The formula for determining the final score is as follows:

$$\bar{X} = \frac{\sum x}{n}$$

The general assessment of the question set $\bar{\boldsymbol{X}}$ is determined by the sum of scores ($\sum \boldsymbol{x}$) and the number of questions (n). The Aiken validity index determines content validity based on expert validators' agreement. The following formula is used to calculate this:

$$\boldsymbol{V} = \frac{\sum \boldsymbol{s}}{\boldsymbol{n}(\boldsymbol{c}-\mathbf{1})}$$

with,

$\boldsymbol{V}$: Aiken's V index

$\boldsymbol{s}$: , the score assigned to each rater minus the the lowest score in the category used ($\boldsymbol{s} = \boldsymbol{r} - \boldsymbol{lo}$)

$\boldsymbol{r}$: the number of validity ratings given by the validators

$\boldsymbol{lo}$: lowest validity judgment number

$\boldsymbol{c}$: highest validity rating score

$\boldsymbol{n}$: number of validators

Once the validator has completed their assessment on the validation sheet, the value of the V Aiken coefficient for each item will be obtained. This value will then be compared with the content validity index value based on the number of rater validators, as outlined in Table V-Aiken in Table 1. In this study, two raters were employed with a rating scale 5. Consequently, the calculated validity coefficient value must meet the V-Aiken table coefficient value's limit for the result to be valid.

Table 1. Aiken Coefficient of Validity (Aiken, 1985)

Rater (n)	Rating Scale					
	2	3	4	5	6	7
	V	V	V	V	V	V
2				1.00	1.00	1.00
3		1.00	1.00	.92	.87	.89
4		1.00	.92	.88	.85	.83
5	1.00	.90	.87	.80	.80	.77
6	1.00	.83	.78	.79	.77	.75
7	1.00	.86	.76	.75	.74	.74
8	.88	.81	.75	.75	.72	.71
9	.89	.78	.74	.72	.71	.70
10	.90	.75	.73	.70	.70	.68
11	.82	.73	.73	.70	.69	.68

The results of the V-Aiken validity analysis indicate the validity of each item.

<u>Reliability</u>

The reliability coefficient was calculated using Cronbach's Alpha formula and categorized according to the reliability criteria proposed by Arikunto (2021), presented in Table 2.

$$the\ r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

Description:

r_{11} : instrument reliability

$the\ \sum \sigma_i^2$: sum of item variances

σ_t^2: total variance

n : the number of items or the number of questions

Table 2. Criteria for Question Reliability (Arikunto, 2021)

Correlation Coefficient	Reliability Criteria
0.00 – 0.20	Very low
0.21 – 0.40	Low
0.41 – 0.70	Moderate
0.61 – 0.80	High
0.81 – 1.00	Very high

<u>Level of difficulty</u>

The difficulty level of the items on the test instrument was evaluated using the following formula:

$$P = \frac{B}{J_S}$$

Description:

P : Level of Difficulty

B : the number of participants who answered the question correctly

J_S : number of all test takers

The item difficulty index is defined by the specifications outlined in Table 3.

Table 3. The criteria for the difficulty level in the question item are as follows (Arikunto, 2021; Mahjabeen et al., 2017).

Range of Level of Difficulty	Criteria Level of Difficulty
0.00 – 0.30	Difficult
0.31 – 0.70	Moderate
0.71 – 1.00	Easy

RESULT AND DISCUSSION

Developing test instruments is divided into four stages: define, design, develop, and disseminate. At the Define stage, needs and student analyses were conducted. The needs analysis process is divided into two categories: material analysis and analysis of learning objectives presented in question indicators. The results of the material analysis and the learning objectives, presented in the form of wave concepts related to biology, are presented in Table 4.

In the student analysis, an investigation was conducted to assess the initial understanding of physics concepts among students majoring in biology. This was achieved by administering conceptual knowledge questions on waves, encompassing general and pure physics concepts. The results indicate that 55% of students can explain the concept of waves in general, 45% of students can explain the concept of sound waves in general, 40% of students can identify the characteristics of sound waves, and only 30% of students can explain the concept of sound waves through application examples.

These results remain in the low category and may impede students' comprehension of advanced topics about waves and their applications in biology. The issue of students' limited comprehension of the concept of waves has been explored by several studies (Hailemariam, 2014; Ryan, Wilcox, & Pollock, 2018; Uwamahoro, Ndihokubwayo, Ralph, & Ndayambaje, 2021). The results indicate that students encounter difficulties with the sub-topics of interference, reflection, refraction, transmission, and phase difference, which are the fundamental concepts of waves (Kanyesigye et al., 2023). Furthermore, students cannot provide an example of applying the concept of waves, particularly sound waves, in their everyday lives (Mabruroh & Suhandi, 2017).

One of the causes of the low understanding of physics concepts among biology students is the use of test instruments as training and assessment media, whose content is still dominant in physics. The formulation of questions also contains a significant amount of calculation material that requires students to memorize numerous formulas and theories without any connection to their scientific field (Toto & Yulisma, 2017). Consequently, to facilitate biology students' comprehension of sound waves, it is essential to adapt the test instruments to align with the specific requirements of biology studies.

The question analysis, item design, and scoring guidelines were formulated at the design stage. The questions were designed in the form of descriptions that required the provision of descriptions of student answers that demonstrated the level of understanding or mastery of the concept of the Wave topic. The lattice of questions contains indicators of competency achievement, indicators of conceptual knowledge, and the number of questions presented in Table 5.

Table 4. Wave Concepts Related to Biology

Wave Topics	Wave Materials Related to Biology	Formulation of Competency Achievement Indicators
1. Wave Concept 2. Concept of Sound Wave 3. Characteristics of Sound Waves 4. Application of sound waves	1. Concept of sound waves 2. Parts of the ear related to the concept of waves 3. Working principle of the ear as a hearing system 4. Mechanism of animal hearing 5. The process of sound in humans	1. Explain the concept of sound waves with examples of applications related to Biology 2. Analyze the parts of the ear through which sound waves pass 3. Explain the interference of the ear and its relation to the concept of Waves 4. Analyze the working mechanism of the ear and its relation to the concept of Waves 5. Explain the working mechanism of the ear and its relation to the concept of Waves 6. Apply the concept of ear sensitivity as a response to the intensity of the sound heard, 7. Analyze the mechanism of bats in recognizing an object through their sense of hearing, 8. Analyze the mechanism of sound in humans

Table 5. Analysis of Test Instrument

Competency Achievement Indicators	Conceptual Knowledge Indicators	Cognitive Level based on Bloom's Taxonomy	Number of Questions
Explain the concept of sound waves with examples of applications related to Biology.	Knowledge of principles and generalizations	C2	1
Analyze the parts of the ear through which sound waves pass	Knowledge of classification and categories	C4	1
Explain the working disorders of the ear and their relation to the concept of Waves.	Knowledge of principles and generalizations	C2	1
Analyze the working mechanism of the ear and its relation to the concept of Waves.	Knowledge of theories, models, and structures	C4	1
Explain the working mechanism of the ear and its relation to the concept of Waves.	Knowledge of theories, models, and structures	C2	1
Apply the concept of ear sensitivity as a response to the intensity of the sound heard.	Knowledge of principles and generalizations	C3	1

Table 5 indicates that the indicators of competency achievement for Sound Waves have been adjusted to align with the field of study of Biology, specifically the human and animal hearing system. The auditory system is a critical component of the biology topic, which encompasses identifying and explaining the various components of the auditory system and the underlying mechanisms of hearing. Based on its functional role, the auditory system identifies and localizes sound sources, enabling humans to perceive and recognize them as specific sounds.

In addition to examining the auditory system, indicators of competency achievement are also aimed at ear sensitivity in response to the intensity of the sound or sound heard. This relates to the noise around humans and the ability of the auditory system to accept or reject it. The achievement of this competency motivates Biology students to study the concept of Sound Waves more deeply because it is in line with the study of Biology. The association of physics concepts with biology studies can undoubtedly stimulate the enthusiasm of biology students to learn, thereby enhancing their comprehension of physics concepts (Fatimah & Ulfa, 2022; Junaidi & Asra, 2019; Sarkity & Sundari, 2020; Ubaidillah, 2018).

Based on the instrument analysis, eight questions were designed and adjusted to the GPA and the achievement of conceptual knowledge indicators. The instrument was prepared with an essay-type test, which aims to describe the questions more broadly to reveal the Physics concept of the topic of Sound Waves. The presentation of the items is made in the form of a conceptual knowledge test instrument table on the topic of sound waves (Table 8). Furthermore, the instrument's feasibility is tested at the development stage, including content validity, item validity, and difficulty level.

<u>Content Validity</u>

The results of the validator's assessment for each item were analyzed using the formula, and the V-Aiken validation index is presented in Table 6. In addition, a summary of input for improvement from validators is presented in Table 7.

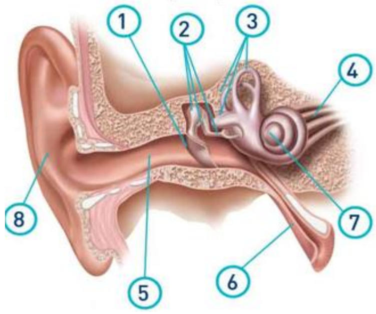
Table 6. Results of Validation of Each Question Item

Item Question	$V_{Aiken's\ table}$	Index of V Aiken counting	Description
1	1	1	valid
2	1	1	valid
3	1	1	valid
4	1	1	valid
5	1	1	valid
6	1	1	valid
7	1	1	valid
8	1	1	valid

Table 7. Summary of Improvements Based on Validator Feedback

Validator Feedback	Example of Improvement on the questions	
	Before revision	After revision
- It is recommended that the appropriate and functional notation, symbols, icons, and images be used to facilitate the understanding of the question. - Furthermore, it is advised that the question's opening sentence be improved to avoid any potential for ambiguity or confusion.	The vast ocean turns out to be inhabited by fantastic creatures of giant size, one of which is the whale, as shown below.  Whales spend a significant portion of their time in the deep ocean. However, as is well known, the deeper one descends into the ocean, the darker the environment becomes (with minimal lighting), which makes it challenging for whales to optimize their eyesight to see their surroundings. Please describe your conceptual understanding of how whales effectively observe their surroundings in the deep sea to detect their prey. (Connect with the concept of sound waves)	Whales are one of the numerous marine mammals that inhabit the ocean. Whales typically spend a significant portion of their time in the deep ocean. However, it is well documented that the deeper one penetrates the seabed, the darker the environment becomes (with minimal lighting). This presents a significant challenge for whales in optimizing their eyesight to see effectively. Based on your understanding of the concept, please describe how whales effectively observe the surroundings of the deep ocean so that they can detect their prey. (Connect with the concept of sound waves)
Adjust questions to the competency achievement indicators	The capacity for sound production is a defining feature of animal life. The diversity of sound production in animals is considerable, with various vocalizations observed across various species. Please provide examples of how animals produce sounds through the respiratory system.	In humans, the vocal cords are the primary sound source at the top of the trachea. The vocal cords play a crucial role in producing the human voice. Based on your understanding, please describe how the human voice is processed and explain why each individual has a unique voice.
Please explain the terms used in the question sentence.	Please explain why the relative size of the eardrum and the resulting oval window can affect pressure magnification in the inner ear.	Please explain why the relative size of the eardrum and the yield of the oval window (entrance to the inner ear from the middle ear) can affect the pressure magnification in the inner ear.

Table 8. Conceptual knowledge test instrument on the topic of sound waves

Subtopics	Competency Achievement Indicators	Conceptual Knowledge Indicators	Problem Items
Concept of Sound Waves	Explain the concept of sound waves with examples of applications related to Biology.	Knowledge of principles and generalizations	Whales are one of the animals that live in the ocean. They spend much of their time in the deep ocean, where the seabed is very dark (minimal lighting). This makes it challenging for them to optimize their eyesight to see around. Based on your understanding of the concept, describe how whales effectively observe the surroundings of the deep ocean to detect their prey. (Connect with the concept of sound waves)
Parts of the ear related to the concept of waves	Analyze the part of the ear traveled by sound waves	Knowledge of classifications and categories	Take a look at the picture below.  The sounds we hear daily have gone through several stages before they can be processed in the human brain. Using the picture above, try to guess which parts of the ear the sound waves pass through so that the hearing process works perfectly. Describe your explanation by analyzing the relationship between sound waves and the hearing process.
	Explain ear disorders and how they relate to the concept of waves	Understanding of classifications and categories	The condition of buzzing or ringing in the ears is often experienced by people suddenly in quiet or silent places. It can sometimes be alarming and worrying. The annoying noises can be heard in one or both ears and can feel near and far. However, when you finish yawning or chewing, sometimes the noise suddenly disappears. Describe why you think this happens. (Relate your explanation by linking the parts and functions of the affected ear to the concept of waves in sound).
Ear working mechanism	To analyze the working mechanism of the ear and its relationship to the concept of waves.	Knowledge of theories, models, and structures	Headsets have become an integral part of our daily lives. Not only for listening to music, these electronic devices are also often used for making phone calls. A headset is very helpful, as it eliminates the need to hold a mobile phone when making a call or reduces the noise when listening to music. However, prolonged use of a headset with a high volume of sound can disrupt the functioning of the ear and lead to deafness.

<table>
<tr><th>Subtopics</th><th>Competency Achievement Indicators</th><th>Conceptual Knowledge Indicators</th><th>Problem Items</th></tr>
<tr><td></td><td></td><td></td><td>Using this information, analyze why this happens! (Relate your explanation to the concept of vibration and waves in sound).</td></tr>
<tr><td></td><td>Explain how the ear works and relates to the concept of the waves.</td><td>Knowledge of theories, models, and structures</td><td>Explain why the relative size of the eardrum and the yield of the oval window (the entrance to the inner ear from the middle ear) can affect the pressure magnification in the inner ear.</td></tr>
<tr><td>The working principle of the ear as an auditory system</td><td>Apply the concept of ear sensitivity in response to the intensity of the sound heard</td><td>Understanding principles and generalizations</td><td>The source's sound intensity decreases with the square of the distance from the source. I assume that the riveting tool is a point source of sound and that the intensity in the table is measured at a distance of 1 m from the source.
<table>
<tr><th>Sound Source</th><th>Sound Level (dB)</th><th>Sound Level (W/cm2)</th></tr>
<tr><td>Pain threshold</td><td>120</td><td>10^{-4}</td></tr>
<tr><td>Rivets</td><td>90</td><td>10^{-7}</td></tr>
<tr><td>Busy traffic</td><td>70</td><td>10^{-9}</td></tr>
<tr><td>Ordinary conversation</td><td>60</td><td>10^{-10}</td></tr>
<tr><td>Car engine noise</td><td>50</td><td>10^{-11}</td></tr>
<tr><td>Sound of radio at home</td><td>40</td><td>10^{-12}</td></tr>
<tr><td>Whispering</td><td>20</td><td>10^{-14}</td></tr>
<tr><td>Friction of leaves</td><td>10</td><td>10^{-15}</td></tr>
<tr><td>Hearing limit</td><td>0</td><td>10^{-16}</td></tr>
</table>
What is the maximum distance from the riveting tool where the sound can still be heard? (ignoring losses due to energy absorption in air).</td></tr>
<tr><td>Animal Hearing Mechanism</td><td>Analyze the mechanism of bats in recognizing an object through their sense of hearing.</td><td>Understanding principles and generalizations</td><td>We are all familiar with the animal in the picture below, a bat.

This creature is a type of nocturnal animal or animal that does most of its activities at night. For an object to be seen clearly, it requires the presence of light and eyes. How do bats detect prey and predators at night?</td></tr>
<tr><td>The process of sound in humans</td><td>To analyze the mechanism of sound in humans.</td><td>understanding of theories,</td><td>The human ear has two distinct parts, each with a vital role. The outer ear is responsible for hearing, while the inner ear is essential for</td></tr>
</table>

Subtopics	Competency Achievement Indicators	Conceptual Knowledge Indicators	Problem Items
		models, and structures	maintaining balance. In light of the information above, please explain the mechanism of sound in humans and the role of the ear as a balance maintainer.

At the validation stage, three questions were revised based on the validator's assessment. These included the use of notation, symbols, icons, and images that were not appropriate, the improvement of the opening sentence of the question to avoid multiple interpretations, the adjustment of the questions to the indicators of achievement of competencies, and the provision of explanations for the terms used in the questions. The three questions were subjected to further revision to fulfill the validity test.

The summary of the validation results indicates that all eight questions are valid, confirming the instrument's suitability for its intended purpose. Test instruments that fulfill the criteria of validity are capable of measuring the variables in question based on the reality of the situation (Sürücü & Maslakci, 2020).

Reliability

The Cronbach's Alpha formula determines reliability. By using this formula, it is known that the reliability of the questions in this study is 0.87. Thus, the reliability of this test instrument is in the high category.

The results of the instrument reliability analysis obtained a high category, which means that the test can provide the same results even though it is used at different times and occasions (Bull, Byrnes, Hettiarachchi, & Downes, 2019; Sürücü & Maslakci, 2020). A test can be reliable if it gives the same results on the same subject at different times. This is in line with Sudjana (2017), where reliability shows the constancy or stability of an instrument.

Difficulty Level

The calculation of the level of difficulty is a measurement of the degree of difficulty of a question (Clark & Watson, 2019). If a question has a balanced level of difficulty, it can be said to be of an appropriate difficulty level (Lumbanraja & Daulay, 2018; Tanjung & Dwiana, 2019). The analysis of the difficulty level of the eight questions revealed that six were moderate difficulty and two were difficult. The questions in the problematic difficulty category were re-examined and revised to be included in the question set. The results of the analysis of the level of difficulty are displayed in Table 9.

Table 9. Results of Analysis of Question Difficulty Level

Question Numbers	Range of difficulty level	Criteria for Level of Difficulty	Conclusion
1, 2, 3, 4, 5, and 8	0.45-0.60	Medium	Accepted
6 and 7	0.20-0.25	Difficult	Revised for reuse

The subsequent aspect of instrument feasibility is the level of difficulty. Lichtenberger, Wagner, Hofer, Stern, and Vaterlaus (2017) describe the difficulty level as falling within high or complex, medium, and low or easy categories. The instrument developed fulfills the medium category with six items and the problematic category with two items (Lichtenberger, Wagner, Hofer, Stern, & Vaterlaus, 2017). It is possible to remove or revise difficult questions to align them with the purpose of the test instrument (Boopathiraj & Chellamani, 2013; Wulaningtyas & Sukanti, 2016).

The results of the overall feasibility test indicate that the eight items of the instrument can be used to train and measure the mastery of physics concepts among biology students, focusing on waves. The material is presented in an integrated manner and related to biology. When students engage with the subject matter in-depth, they are more likely to consider the meaning of the material and store it in their long-term memory, thereby facilitating the formation of conceptual knowledge (Bartoszewski & Gurung, 2015; Koster & Vermunt, 2020). Students who possess a comprehensive and profound comprehension of concepts can utilize them to resolve challenges encountered in their daily lives (Ramos et al., 2013).

The final stage of instrument development is the dissemination stage. Test items that have been demonstrated to meet the indicators of achievement of Physics competencies for Biology Department students, with content tailored to the field of Biology, and have undergone instrument feasibility testing, which includes content validity, reliability, and level of difficulty, can be distributed and used to measure the mastery of the concept of Waves by Biology Department students at other universities that require this instrument. Test instruments that have met content validity and feasibility testing can be used for future tests (Rahmawati, Rustaman, Hamidah, & Rusdiana, 2018).

Understanding the concept of physics as a whole, with its implementation in biology, will facilitate the mastery of science, as students can relate to the material in their own scientific field (Wulandari et al., 2022). Integrating physics concepts into the field of biology represents an effort to cultivate interdisciplinary knowledge, which is a crucial asset for students in the contemporary academic landscape (Wulandari et al., 2022).

CONCLUSION

The test instrument on waves developed eight items based on the scientific field of biology: the human and animal hearing system. The conceptual knowledge test instrument is feasible regarding content validity, reliability, and difficulty level. This means that the test instrument can be used to measure the conceptual knowledge of waves among students majoring in biology. Physics test instruments tailored to the interests and fields of science pursued by biology students can assist them in comprehending physics concepts accurately. The study's findings revealed limitations in identifying biology courses that are more diverse and suitable for elucidating the concept of waves in greater depth. Consequently, future research should aim to conduct in-depth analyses of biology studies that can be genuinely associated with the concept of waves. It is evident that adapting physics concepts to specific scientific fields is a valuable strategy for developing interdisciplinary knowledge. Consequently, recommendations for future research may include the creation of analogous test instruments for other physics materials.

ACKNOWLEDGMENTS

This work was supported through a 2023 DRTPM with contract number 038/E5/PG.02.00.PL/2023 by the Directorate General of Resources for Science Technology and Higher Education of the Republic of Indonesia.

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