

The Creation of A Three-Tier Multiple-Choice Diagnostic Test Instrument to Identifying High School Students' Misconceptions Regarding Biological Virus Material

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Abstract: This study aims to develop a diagnostic test instrument with three tiers focusing on viral material. Research and Development (R&D) constitutes a form of applied research. The participants for the Field Test were Class X students at SMAN 22 Bone, while those for the subsequent test were Class X students at SMAN 19 Bone. Interviews and documentation serve as the primary research methods employed in this study. A three-tier multiple-choice format is characterized by three levels of questioning within the multiple-choice framework. The resultant diagnostic test instrument comprises three tiers: the first tier includes questions, the second tier offers alternative explanations, and the third tier assesses respondents' confidence levels in selecting answers and providing justifications. The outcomes of this research include answer keys, test questions, and question grids as integral components of the instrument. This study demonstrates the validity of the developed instrument through validation conducted by expert validators. The reliability test yielded a robust average value of 0.91. Only 24 out of the 40 questions were deemed valid during the field test phase. Findings revealed that students exhibited an average misconception rate of 47.2%, spanning two indicators derived from the 40 questions. Notably, misconceptions were prominent in the discussion sub-topic concerning the earliest discovery of viruses and methods for distinguishing viruses and bacteria, with an average misconception rate of 56.8% in viral material. Developing a three-tier diagnostic test effectively identified students' misconceptions regarding viral material, indicating suitability and efficacy for educational application.

Keywords: Misconceptions; Senior High School; Three Tier Diagnostic Tests; Virus Material.

Introduction

The delineation of learning objectives is articulated within Permendikbud Number 21 of 2016, encompassing various aspects such as comprehension, application, analysis, and evaluation of conceptual knowledge. Among these objectives is attaining a proficient and accurate understanding of existing concepts among students [1].

During learning activities, students frequently encounter challenges, including difficulties comprehending concepts. Inadequate depth, emphasis, and acceptance of newly introduced concepts can contribute to learners' misconceptions, which may persist if not sufficiently addressed [2].

This misinterpretation can be classified as misconceptions or challenges stemming from students' struggles to grasp established concepts, thus making misconceptions a prevalent learning obstacle. Several factors contribute to the prevalence of misconceptions among students, such as their prior experiences, which may inadvertently foster misconceptions. Additionally, teaching methodologies employed by educators can also serve as catalysts for misconceptions among students [3].

Misconceptions arise when there is a disparity between students' preexisting conceptions and established scientific principles. Experiences can contribute to the formation of misconceptions. The Three-Tier multiple-choice diagnostic test is an effective tool for identifying

misconceptions in students, characterized by three levels within its multiple-choice format [4].

The initial tier comprises conventional multiple-choice queries in the context of three-tier multiple-choice questions. The subsequent tier involves presenting options for reasoning associated with the inquiries from the first tier. The third tier involves affirmations, where students indicate their confidence levels regarding answers provided by previous students in the preceding two tiers.

The three-tier multiple choice diagnostic test offers several advantages: Firstly, it facilitates comprehensive diagnosis of students' misconceptions, enabling a thorough understanding of their learning gaps. Secondly, educators can utilize this test to underscore essential course content during instruction. Thirdly, the application of this test in lesson planning can lead to a reduction in student misconceptions by promoting more effective instructional strategies. Additionally, researchers can leverage this diagnostic tool to estimate misconception scores and evaluate the instrument's validity, among other potential benefits [5].

Suboptimal learning achievements have piqued researchers' interest in identifying student misconceptions. Accurately discerning the presence of misconceptions necessitates a test instrument capable of providing precise data on such misconceptions, thereby furnishing educators with a tool for gauging and addressing these misconceptions. The researcher selected Bone Regency,

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specifically SMAN 22 Bone, as the research site due to its noted instances of low learning outcomes, particularly evident in Class X, where many students fail to meet the minimum passing grade (KKM) in daily assessments of viral material. This predicament is likely attributable to students' misconceptions.

This study aims to create a three-tier multiple-choice diagnostic test aimed at identifying students' misconceptions concerning biological virus material at SMAN. The test's effectiveness will be evaluated in terms of validity, reliability, difficulty level, and differentiability. Additionally, the research aims to understand the profile of Class X SMAN students regarding virus material. Developing a test instrument that enables teachers to assess students' comprehension levels and misconceptions is imperative, particularly in biology education, where virus material presents intricate concepts prone to misunderstanding among students.

Research Methods

Research and Development (R&D) entails a systematic progression involving multiple research phases to refine educational tools through iterative cycles. This study employed Tessmer's formative research development model, derived from Sugiono [6]. This model guides the iterative development process, which includes various stages and methods. Specifically, a three-tier format diagnostic test instrument focusing on virus material was utilized in Class X SMAN.

The researcher engaged students from Class X at SMAN 19 Bone and SMAN 22 Bone for this study. During the field trial, researchers conducted one-on-one sessions involving three students of low, medium, and high proficiency levels. Subsequently, nine students participated in the small group phase of the field trial, comprising two students each from low, medium, and high proficiency categories. In total, 44 students were involved in the Field Test stage of the field trial.

In this study, researchers employed the test method as a means of data collection. Quantitative data extracted through the SPSS program encompassed validity, reliability, difficulty level, and differentiation information.

The formula utilized to assess the validity value of the evaluator's assessment, adapted from Akbar, is outlined as follows.

$$V_1 = \frac{TS_e \times 100\%}{TS_h}$$

Description:

V_1 = Validation score from validator 1

TS_h = Total maximum score

TS_e = Total score from validators

The validity ratings provided by each validator can subsequently be utilized to compute the aggregate validity score using a formula adapted from Akbar.

$$V = \frac{V_1 + V_2}{2} = \dots\%$$

Description:

V_1 = Validation score from validator 1

V_2 = Validation score from validator 2

Table 1 below is an interpretation of Akbar's [7] percentage

value of product validity:

Table 1. Interpretation of Product Validity

Score interval	Category of validity
85.01%-100%	Very Valid
70.01%-85%	Valid
50.01%-70%	Less Valid
01.00%-50%	Invalid

The formula used to determine the empirical validity value is:

$$R_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}}\sqrt{\{N\sum Y^2 - (\sum Y)^2\}}}$$

Description:

r_{xy} = Correlation coefficient between variable X and variable Y

N = Number of test takers

X = Student score for each item

Y = Total student score

If r calculated > r table, the item is valid.

An effective assessment is characterized by accurate measurements, necessitating the evaluation of its consistency or reliability. At this juncture, test takers determine the reliability of scores, a crucial stage in research. Reliability is vital as it indicates that the test comprises valid questions [8].

Researchers utilize the Kuder and Richardson 20 (KR-20) formula to assess the reliability of tests, mainly focusing on internal consistency, especially in the context of multiple-choice questions [9]. The KR-20 reliability testing employs the subsequent formula.

$$KR\ 20 = \frac{N}{N-1} \times \frac{V - \sum (p \cdot q)}{v}$$

KR 20: Kuder Richardson 20

N: Number of questions in the test

V: Standard of deviation

P: Proportion of correct answers on the test (number of correct answers/total test subjects)

q: Proportion of the number of errors on the test

The following is the interpretation of the reliability value adaptation from Arikunto [10]:

Table 2. Interpretation of Reliability

Intervals	Criteria
0.00-0.20	Very low
0.20-0.40	Low
0.40-0.60	Medium
0.60-0.80	High
0.80-1.00	Very high

The question items have a level of difficulty as the testing formula that will be carried out according to Riyani [11] as follows:

$$TK = \frac{S_A + S_B}{n \max}$$

Description:

DP = Discriminating power number

SA = Sum of upper group scores

- SB = Sum of lower group scores
- n = Number of upper and lower group students
- max = Maximum score of each item

Table 3. Interpretation of Level of Difficulty

The magnitude	Interpretation
0.00-0.30	Difficult
0.31-0.70	Medium
0.21-1.00	Easy

The discriminatory power of each test item facilitates the ability to differentiate between students of varying intelligence levels, such as those with lower or higher abilities. The discrimination index (D) quantifies this differentiation, expressed numerically. A formula exists for determining the discriminatory power of each test item:

$$DP = \frac{S_A + S_B}{\frac{1}{2} n \max}$$

Description:

- DP = Discriminating power number
- SA = Sum of upper group scores
- SB = Sum of lower group scores
- n = Number of upper and lower group students
- max = Maximum score of each item

Sudijono [12] divides the interpretation of discriminating power into several ranges of index numbers.

Table 4. Interpretation of Index Number

The magnitude	Interpretation
0.00-0.20	Weak differentiating power
0.21-0.40	Moderate differentiating power
0.41-0.70	Strong differentiating power
0.71-1.00	Extreme discriminating power
Negative sign	Negative discriminating power (very poor)

The following table is the students' misconception profile categorized based on the combination of students' answers:

Table 5. Three-Tier Diagnostic Test Answer Combination Analysis

Problem Level Analysis	Answer Type			Category
	First Level (answer)	Second Level (Reason)	Third Level (Belief)	
	Correct (1)	Correct (1)	Sure (1)	Understand concept
	Correct (1)	Correct (1)	Not sure (0)	Does not understand the concept
	wrong (0)	Correct (1)	Not sure(0)	Does not understand the concept
Three-Tier Diagnost	Correct (1)	wrong (0)	Not sure (0)	

ic Text	wrong (0)	wrong (0)	Not
	wrong (0)	Correct (1)	Sure(1)
	wrong (0)	wrong (0)	Sure(1)
	wrong (0)	wrong (0)	Sure(1)

Results and Discussion

The researchers formulated questions about virus material in this work, aligned explicitly with KD. 3.4 of Curriculum 2013 for Grade X. Initially, a pool of 40 items was developed and subsequently subjected to various testing phases, including expert reviews, one-on-one assessments, small group evaluations, and field trials. Following scrutiny by a biology lecturer from Makassar State University, acting as a validator, the test instrument demonstrated commendable product validity, reaching 85.71%. Experiments conducted during the one-on-one, small group, and field test phases garnered empirical validity data. Furthermore, these trials aimed to ascertain the reliability of the instrument.

Based on the one-on-one stage test analysis results, 27 items were deemed valid, with a reliability coefficient of 0.90 indicating reliability. Of these, 12 items exhibited solid differentiation, while 15 were considered poor.

The lack of comprehension among students regarding the questions or provided material is the singular factor leading to the invalidity of existing questions. This discrepancy results in divergent perceptions among students. Invalid questions necessitate elimination as they cannot be recycled [13].

The small group stage test analysis yielded 25 valid questions with a reliability coefficient of 0.88, indicating reliability. Among these, 11 items were rated as having a moderate difficulty level, while seven items were classified as complex, five as easy, and two as very easy. Additionally, two items were categorized as having negative differentiation, and three questions fell into the poor category, nine into the sufficient category, nine into the good category, and two into the excellent category.

During the field test stage, the analysis revealed 24 valid questions with a reliable reliability coefficient 0.91. Among these questions, two were classified as easy, 14 as moderate, six as complex, and two as too difficult. Additionally, 14 questions exhibited strong differentiation, 15 demonstrated good differentiation, 3 showed sufficient differentiation, and 2 had poor differentiation.

Derived from the student test results, it is evident that the test instrument is suitable for identifying students' misconceptions regarding virus material. The subsequent presentation illustrates the percentage breakdown of students' conceptual understanding of virus material.

Table 6. Results of Answer Combination Analysis Diagnostic Test

Category	Average	Percentage%
Understand the concept	11.45	25.65
Don't understand the concept	11.95	26.96
Misconceptions	20.79	47.20

Table 7. Diagnostic Test Question Instrument for Virus Material

Indicator	About	Percentage Misconceptions
3.4.1 Describe the characteristics of viruses based on literature review/theory	<p>A biologist who first recognized that tobacco plants were attacked by very small organisms other than bacteria is...</p> <p>a. Adolf Mayer b. Dimitri Ivanowsky c. Martinus Beijerinck d. Wendell Stanley</p> <p>What is the reason for your answer to the question above?</p> <p>a. In his experiment, the mosaic disease agent could not be cultured on a nutrient medium b. In his experiments, he compared viruses with other microorganisms and proved that viruses are smaller than bacteria c. Can prove that viruses can attack tobacco plants d. Observations made about very small organisms that attack plants e. Other reasons:</p> <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <p>a. Sure b. Not sure</p>	43.1%
3.4.1 Describe the characteristics of viruses based on literature review/theory	<p>The additional envelope on the virus affects its malignancy, which consists of...</p> <p>a. Tail fibers b. Capsid c. Capsomeres d. Membrane cover</p> <p>What is the reason for your answer to the question above?</p> <p>a. There are glycoproteins on the membrane cover as receptors b. Capsid is a protein envelope in bacteriophages c. On the membrane cover, there is an additional sheath d. Capsomeres are located below near the tail fibers e. Other reasons:</p> <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <p>a. Sure b. Not sure</p>	56.8%
3.4.1 Describe the characteristics of viruses based on literature review/theory	<p>The correct statements for numbers 3 and 5 are...</p> <p>a. Number 3 functions as a storage, and number 5 functions as a means of viral movement. b. Number 3 serves as a carrier of genetic material, and number 5 serves as a means of injecting the virus. c. Number 3 and number 5 are used by the virus as a means of attachment and a place for injecting DNA into host cells d. Number 3 and number 5 are used by the virus as a means of movement so that it can attach to the host cell</p> <p>What is the reason for your answer to the question above?</p> <p>a. Numbers 3 and 5 are used to store some of the DNA and as a means of movement b. Numbers 3 and 5 are used as carriers of material from inside the capsid and as a means of movement for the virus c. Numbers 3 and 5 are used as carriers of genetic material and as injectors d. Number 3 and 5 as the envelope and tail fibers, there is a base plate as an injector e. Other reasons:</p> <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <p>a. Sure b. Not sure</p>	47.7%
3.4.2 Detailing the structure of viruses based on literature	Take a look at the picture below!	54.5%

review/theory



A B

From the picture of the virus above, which distinguishes viruses A and B, we can see that

- a.Type of virus nucleic acid
- b.The shape of the virus capsid
- c.Genetic material of the virus
- d.Virus body envelope

What is the reason for your answer to the question above?

- a.Virus A possesses a lipid envelope, while Virus B possesses a protein envelope
- b.The virus in picture A is helix-shaped, and picture B is round-shaped
- c.Virus A has DNA, and virus B has RNA
- d.Virus A capsid is elongated, and virus B capsid is circular
- e.Other reasons:

Are you sure of your choice of answers to the questions above and your reasons?

- a. Sure
- b. Not sure

<p>3.4.2 Detailing the structure of viruses based on literature review/theory</p>	<p>If there are bacteria and viruses in a solution, how can the bacteria and viruses be separated?</p> <ul style="list-style-type: none"> a.Look at the morphological size of viruses and bacteria. b Freeze the solution c. Inserting antibiotics d.Staining the solution <p>What is the reason for your answer to the question above?</p> <ul style="list-style-type: none"> a. Specific enzymes produced by antibiotics kill viruses b.By looking at the size, if the virus may be smaller than the bacteria c.Viruses can die if frozen, and bacteria cannot d.Antibiotics only kill bacteria by inhibiting specific enzymes e.Other reasons: <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <ul style="list-style-type: none"> a. Sure b. Not sure 	<p>43.1%</p>
<p>3.4.3 Classify viruses with their genetic material based on literature review/theory.</p>	<p>The characteristics of viruses that are not found in other organisms are...</p> <ul style="list-style-type: none"> a.Can solely be observed through the utilization of a microscope b.Only reproduce in living cells c. Can move freely anywhere d.Lives parasitically <p>What is the reason for your answer to the question above?</p> <ul style="list-style-type: none"> a.Viruses can cause dangerous diseases b.Viruses cannot crystallize themselves c.Viruses only have a protein envelope and DNA/RNA d.Viruses do not have enzymes and ribosomes to metabolize e.Other reasons: <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <ul style="list-style-type: none"> a. Sure b. Not sure 	<p>50%</p>
<p>3.4.3 Classify viruses with their genetic material based on literature review/theory.</p>	<p>Each type of virus can infect cells from a limited range of hosts; for example, rabies virus can only infect a limited number of mammal species. The host cell limitation of a virus is called...</p> <ul style="list-style-type: none"> a. Host range b. Host cell c. Temporary host d. Actual host <p>What is the reason for your answer to the question above?</p> <ul style="list-style-type: none"> a.There are different hosts in the virus b.Evolution of virus recognition system with suitability c.One virus can inject multiple hosts 	<p>52.2%</p>

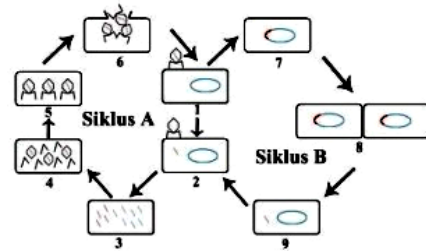
- d. A temporary host cannot infect several species
 - e. Other reasons:
- Are you sure of your choice of answers to the questions above and your reasons?
- a. Sure
 - b. Not sure

3.4.3 Classify viruses with their genetic material based on literature review/theory.	Viruses cannot live freely but must live parasitically in host cells. Therefore, to maintain the virus, it is used... a. Petri dish b. Agar nutrient c. Chicken egg embryo d. Dead mice What is the reason for your answer to the question above? a. A chicken egg embryo is a cell b. Viruses are associated with disease c. Petri dish has a host cell d. Agar nutrients are living things e. Other reasons: Are you sure of your choice of answers to the questions above and your reasons? a. Sure b. Not sure	56.8%
3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction	What is the nature of the new virus that results from the lysis reproduction stage of the virus in the host cell... a. Different from the parent virus b. Slightly different from the parent virus c. Almost the same as the parent virus d. Same as the parent virus What is the reason for your answer to the question above? a. Viruses can replicate b. There are nucleic acids that carry the genetic information of the virus c. The properties of the parent virus will be passed on to the new virus when it reproduces d. Viruses carry different diseases e. Other reasons: Are you sure about your answer choices and your reasons? a. Sure b. Not sure	47.7%
3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction	The cycle in viral reproduction that occurs rapidly and causes the rupture and death of host cells due to the formation of new viruses is called... a. Lytic b. Absorption c. Penetration d. Lysogenic What is the reason for your answer to the question above? a. There is an absorption (attachment) phase b. The host cell does not have good defenses c. Lytic is the process of virus reproduction d. Death and rupture of the host cell e. Other reasons: Are you sure about your answer choices and your reasons? a. Sure b. Not sure	54.5%
3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction	When the virus is in the lysogenic stage, why does the body not feel sick... a. There is a merger of viral and bacterial DNA b. No new virions are formed c. Bacteriophages are still present in the cell d. Bacteria can fight the virus What is the reason for your answer to the question above? a. Cells are strong against virus infection b. The immune system cannot detect foreign bodies c. Bacteriophages can be used to attack viruses d. Host cells have a solid immune system	54.5%

- , e. Other reasons:
- Are you sure about your answer choices and your reasons?
- a. Sure
- b. Not sure

3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction 36.3%

Look at the scheme below! (Use the scheme below to answer questions 19-21.)



The phase that shows the virus injecting genetic material into the host cell so that the viral protein capsid becomes empty (dead) occurs in number...

- a. 1
 - b. 2
 - c. 3
 - d. 4
- What is the reason for your answer to the question above?
- a. The capsid is empty at the 4th cycle
 - b. There is a fusion of the virus into the object
 - c. The protein capsid dies as it is transmitted to the host cell
 - d. In this phase, the tailcoat of the virus contracts through the wall
 - e. Other reasons:

- Are you sure of your choice of answers to the questions above and your reasons?
- a. Sure
- b. Not sure

3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction 43.1%

Consider the following statements:

- A. In this cycle, the viral DNA inserts into the bacterial chromosome through recombination
- B. An infected cell can quickly produce a large population of bacteria that carry the virus
- C. Does not form new virions
- D. Viruses can live together with bacteria

The above statement is a unique feature of the cycle shown by ...

- a. Cycle A, lysogenic
 - b. Cycle B, lytic
 - c. Cycle A, lytic
 - d. Cycle B, lysogenic
- What is the reason for your answer to the question above?
- a. Cycle A is adsorption, the attachment of viral genetic material
 - b. Virus injects genetic material into the host cell Virus injects genetic material into the host cell
 - c. Does not produce offspring
 - d. Insertion of viral and bacterial DNA occurs
 - e. Other reasons:

- Are you sure of your choice of answers to the questions above and your reasons?
- a. Sure
- b. Not sure

3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction 36.3%

The correct sequence shown by the numbers 1-2-3-4-5-6 is

- a. Adsorption, assembly, penetration, replication, synthesis, and lysis
- b. Adsorbi, penetration, replication, synthesis, assembly, and lysis
- c. Synthesis, assembly, lysis, adsorption, penetration, and replication
- d. Assembly, adsorption, lysis, penetration, replication and synthesis

- What is the reason for your answer to the question above?
- a. The picture shows the virus assembling its body, consisting of head, tail, virus attachment, injection of viral genetic material, multiplication, cells making viral components, and tail fibers, and release is marked by host cell rupture.
 - b. The picture shows virus attachment, injection of viral genetic material,

- multiplication, cells making viral components, virus assembling its body consisting of head, tail, and tail fibers, and release marked by rupture of host cells
 - c.The picture shows cells making virus components, cells making virus components, and tail fibers, the release marked by host cell rupture, virus attachment, injection of viral genetic material, multiplication
 - d.The picture shows cells making viral components, viral attachment, the release marked by host cell rupture, injection of viral genetic material, multiplication, cells making viral components
 - e.Other reasons:
- Are you sure of your choice of answers to the questions above and your reasons?
- a. Sure
 - b. Not sure

3.4.4. Describe comparing the lytic cycle with the lysogenetic cycle in viral reproduction	Below is the difference between the lytic cycle and the lysogenetic cycle.	45.4%															
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 5%;">No</th> <th style="width: 45%;">Lytic cycle</th> <th style="width: 50%;">Lysogenetic cycle</th> </tr> </thead> <tbody> <tr> <td>a</td> <td>There is an incorporation phase</td> <td>There is an assembly phase</td> </tr> <tr> <td>b</td> <td>Bound to the chromosome</td> <td>Not bound to the bacterial chromosome</td> </tr> <tr> <td>c</td> <td>Long time required</td> <td>Short time required</td> </tr> <tr> <td>d</td> <td>Inactivates bacteria first</td> <td>Combines bacterial genetic material with virus</td> </tr> </tbody> </table>	No	Lytic cycle	Lysogenetic cycle	a	There is an incorporation phase	There is an assembly phase	b	Bound to the chromosome	Not bound to the bacterial chromosome	c	Long time required	Short time required	d	Inactivates bacteria first	Combines bacterial genetic material with virus	
No	Lytic cycle	Lysogenetic cycle															
a	There is an incorporation phase	There is an assembly phase															
b	Bound to the chromosome	Not bound to the bacterial chromosome															
c	Long time required	Short time required															
d	Inactivates bacteria first	Combines bacterial genetic material with virus															
	<p>What is the reason for your answer to the above question?</p> <ul style="list-style-type: none"> a.Lysozyme is produced in the lysis cycle, and the lysogenetic cycle, one of the prophage genes encodes a protein that prevents transcription. b.In lytic, the host cell dies, and in lysogenic, the host does not die c.Lytic undergoes a merger phase, and lysogenic forms new virions d.Lytic and lysogenic cycles depend on whether or not they are bound to chromosomes e.Other reasons: <p>Are you sure of your answer choice and your reasoning?</p> <ul style="list-style-type: none"> a. Sure b. Not sure 																
3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies	<p>Viruses with an RNA core that can serve as a mold to form DNA copies are called... viruses.</p> <ul style="list-style-type: none"> a.Tobacco mosaic virus b.Adenovirus c.Retrovirus d.Papovavirus <p>What is the reason for your answer to the question above?</p> <ul style="list-style-type: none"> a.RNA can be a mold for DNA b. Has reverse transcriptase enzyme c.Viruses can print RNA d. Viruses can copy DNA , e. Other reasons: <p>Are you sure about your answer choices and your reasons?</p> <ul style="list-style-type: none"> a. Sure b. Not sure 	45.4%															
3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies	<p>Among the false statements regarding the basis of virus classification are...</p> <ul style="list-style-type: none"> a.The movement of viruses in the wild b.Types of virus nucleic acid c. Immunological properties of viruses d. The content of certain enzymes possessed <p>What is the reason for your answer to the above question?</p> <ul style="list-style-type: none"> a.Viruses do not spread in the wild b. Viruses only move inside the human body c.In the classification, there is no such feature d. Viruses cannot live alone, and viruses need host cells , e. Other reasons: <p>Are you sure about your answer choices and your reasons?</p> <ul style="list-style-type: none"> a. Sure b. Not sure 	50%															

3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies

The correct pair of virus names and structures is a number...

43.1%

Name	Image
1. TMV virus	
2. Adenovirus	
3. Rhabdovirus	
4. Poxvirus	

- a. 1 and 2
- b. 1 and 3
- c. 2 and 4
- d. 3 and 4

What is the reason for your answer to the question above?

- a. TMV is oblong, and rhabdovirus is polyhedral
- b. Adenovirus is polyhedral, and Papovavirus is oval-shaped
- c. Rhabdovirus is a T4 image, and TMV is rod-shaped
- d. Rhabdovirus is a T-shaped virus, and Poxvirus is elliptical in shape
- e. Other reasons:

Are you sure of your choice of answers to the questions above and your reasons?

- a. Sure
- b. Not sure

3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies

The incorrect pairing of the name of the virus and the disease it causes is...

54.5%

Virus	Diseases caused
a. Flavivirus	Influenza
b. Paramyxo virus	Measles
c. Poliovirus	Polio
d. Retrovirus	AIDS

What is the reason for your answer to the above question?

- a. The cause of AIDS is HIV
- b. Paramyxovirus is the mumps virus
- c. Flavivirus causes dengue fever
- d. Dengue fever is caused by flaviviruses
- e. Other reasons:

Are you sure about your answer choice and your reason?

- a. Sure
- b. Not sure

3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies

Take a look at the statements below!

52.2%

- 1. Viruses in poultry attack pigs
 - 2. H5N1 virus attacked poultry
 - 3. Symptoms of high fever, coughing, shortness of breath, and abdominal pain occur
 - 4. Viruses in pigs attack humans through saliva and feces
- Outline the process by which avian influenza viruses invade the human body...

- a. 1-3-2-4
- b. 1-2-3-4
- c. 1-2-4-3
- d. 2-1-4-3

What is the reason for your answer to the question above?

It needs poultry and pigs as intermediaries before infecting humans.

Are you sure about your answer choice and your reason?

- a. Sure
- b. Not sure

3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health

The H5N1 virus that causes avian influenza is an animal disease or influenza that attacks poultry from migratory birds. Because avian influenza can attack humans, in order to cause an outbreak or epidemic in humans, the H5N1 virus must be used.

43.1%

- a. Be able to evolve quickly

aspects and theoretical studies	<p>b. Have strong body defenses c. It can be transmitted from birds to humans d. Able to send to all organisms</p> <p>What is the reason for your answer to the question above?</p> <p>a. Strong body defense can survive in extreme weather b. Viruses mutate and spread rapidly c. A strong immune system is needed to fight viral infections d. Viruses can evolve in a short period , e. Other reasons:</p> <p>Are you sure about your answer choice and your reason?</p> <p>a. Sure b. Not sure</p>	
3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies	<p>One of the beneficial roles of viruses is to correct genetic disorders, for example, ADD (Adenosine Deaminase Deficiency), which causes a person to have no immune system because there is no AD (Adenosine Deaminase) enzyme is...</p> <p>a. Interferon b. Chemotherapy c. Genetic engineering d. Vaccines</p> <p>What is the reason for your answer to the question above?</p> <p>a. Chemotherapy can correct genetic disorders b. Genetic engineering can improve the arrangement of nitrogenous bases c. Vaccines are used to strengthen the immune system d. It can be used as immunotherapy , e. Other reasons:</p> <p>Are you sure about your answer choice and your reason?</p> <p>a. Sure b. Not sure</p>	43.1%
3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies	<p>Vaccines that can be given orally (by mouth) are vaccines to prevent disease outbreaks...</p> <p>a. Smallpox b. Polio c. Meningitis d. TBC</p> <p>What is the reason for your answer to the question above?</p> <p>a. Diseases that attack the bones b. The virus from the lungs exits through the mouth c. In order not to feel pain , d. Virus replication occurs in the digestive tract , e. Other reasons:</p> <p>Are you sure of your choice of answer to the question above and your reason?</p> <p>a. Sure b. Not sure</p>	43.1%
3.4.5. Conclude the role of viruses in life-based on experience (existing problems) in health aspects and theoretical studies	<p>Proteins produced by animals or cultured cells in response to viral infection to inhibit viral replication in cells are called...</p> <p>a. Chemotherapy b. Antibodies c. Interferon d. Vaccines</p> <p>What is the reason for your answer to the question above?</p> <p>a. Can help other cells to resist the influence of invading viruses b. May inhibit by eating the virus c. Kills virus cells thus inhibiting virus growth d. Chemotherapy can kill and inhibit cancer cells , e. Other reasons:</p> <p>Are you sure of your choice of answers to the questions above and your reasons?</p> <p>a. Sure b. Not sure</p>	36.3%

The instrument development process commences with structured by examining subject matter, question indicators, crafting a grid of three-tier diagnostic test queries, and question level categories spanning C1-C6. Following

the arrangement of the question grid, 40 three-tier diagnostic test questions are formulated, encompassing test queries, answer options, rationale choices, confidence levels, and corresponding answer keys.

All crafted questions will undergo utilization across the expert review, one-on-one, small group, and field test phases. Across these four stages, items conducive to serving as a diagnostic test instrument for misconceptions will be acquired. Evaluating question quality at each stage will serve as the criterion for item selection.

The assessment of question quality through item analysis commences with examining the validity coefficient associated with each question. Should a question demonstrate invalidity, its quality is inherently compromised. However, if the validity coefficient is deemed sufficient, the question's quality is further evaluated by scrutinizing its difficulty level and discriminatory power [14].

Questions failing to meet the criteria for validity should be excluded as they are unsuitable for assessing the intended competencies [15]. This aligns with the assertion [16] that questions failing to meet validity criteria should be discarded and not reused, as they fail to measure the intended constructs. Moreover, [17] succinctly emphasizes the importance of considering validity and reliability in developing research instruments. These factors serve as primary considerations in the selection and refinement of questions.

The reliability assessment of questions employs those categorized as valid following the validity assessment. In essence, items identified as invalid during the validity test must be excluded from the reliability assessment [18]. Building upon this premise, the reliability evaluation conducted during the one-on-one, small group and field test phases exclusively utilized valid items.

The reliability values at the one-to-one and small group stages demonstrate a significant disparity compared to those at the field test stage, with a notable interval distance observed. The variation in test reliability, whether high or low, is impacted by the length of the instrument or the total number of items [19]. This finding aligns with the study's outcomes, wherein the one-to-one stage, comprising 40 items, exhibited the highest test reliability value. Similarly, the small group stage, featuring 27 items, demonstrated a notably high test reliability value. In contrast, the reliability value at the field test stage falls within the medium range, attributed to the smaller number of questions, precisely 24 items.

The difficulty level of questions progresses with noticeable variation across stages from the one-to-one stage to the field test stage. Initially, questions were divided into only two categories—easy and medium—at the one-to-one stage. Subsequently, during the small group stage, questions categorized as difficult emerged. Conversely, there is a well-balanced distribution among difficult, medium, and easy questions at the field test stage.

The number of students participating in the test determines the item difficulty index. The diverse range of students leads to diverse responses, consequently influencing the distribution of question categories. This is because the difficulty index of each item is derived from the ratio of student scores on the question to the total number of students who attempt the question [20].

The examination of the differential power of the questions reveals a correlation with the validity of the questions. This correlation is evident in the one-to-one stage, where 13 items were deemed invalid. Similarly, during the small group stage, two items were found to be invalid [21]. The determination of the question's differentiation index is computed using the biserial point correlation index, indicating a parallel methodology with the validity test. This underscores the relationship between the level of validity and differentiation.

Drawing upon pertinent references, the item selection process at each testing stage is conducted with an initial focus on prioritizing the validity of the questions. Subsequently, the differential power index is assessed. Both evaluations serve as crucial determinants in the decision-making process regarding the selection or elimination of questions.

Question reliability holds significance as a criterion; however, test reliability values are assessed collectively, presenting a value indicative of the entire test. The item difficulty index influences the quality of test items and warrants attention, primarily for delineating the item difficulty category. A question can possess good difficulty quality when it demonstrates a balanced representation across difficulty categories, encompassing manageable, medium, and challenging levels.

Following the one-to-one stage trial, only 27 items remained from the initial pool of 40 three-tier diagnostic test questions. Similarly, the small group trial yielded 25 questions for advancement to the field test stage. In turn, the field test stage generated 24 items, which will undergo analysis to unveil the amalgamation of responses, elucidating the profile of students' conceptual comprehension regarding virus material.

Questions number 9 and 13 exhibited a notable percentage of misconceptions. The highest rate of misconceptions was observed in item number 9 (56.2%), corresponding to the indicator concerning the discussion related to the first discovered virus, and in item number 13 (56.2%), representing the indicator regarding the prediction of methods for separating viruses and bacteria.

This indicates that students often encounter challenges and sometimes cannot establish connections between concepts. Incomplete reasoning may stem from inadequate or partial information acquired by students. Consequently, this can lead to erroneous conclusions and the proliferation of misconceptions among students [22].

Many students may encounter misconceptions regarding certain concepts, particularly those that cannot be directly practiced or experienced. Furthermore, teachers anticipate students' ability to reconstruct their knowledge in the learning process independently. Nonetheless, this remains challenging for most students, potentially resulting in incorrect conclusions regarding the concepts being taught [23].

The culmination of this instrument development endeavor is a three-tier diagnostic test instrument comprising 25 items. Despite the uneven distribution of indicator questions, with some indicators represented by only one question number, this is not deemed problematic. The nature of the development of this diagnostic test instrument is focused on product-based research rather than solely on content fulfillment. Throughout each stage of

instrument development, item analysis is conducted to serve as a foundation for selecting and refining questions, ensuring the production of high-quality items. High-quality test items, even if few in number, are more beneficial than numerous low-quality items[24].

The diagnostic test instrument for virus material, initially comprising 40 questions, underwent testing stages, including expert reviews, one-on-one trials, small group trials, and field tests. Subsequently, it yielded 24 questions demonstrating satisfactory validity, reliability, difficulty levels, and differentiation categories.

The questions generated in this study serve as a valuable resource for designing diagnostic tests to identify student misconceptions contingent upon the context of the testing scenario. As noted by [25], despite an instrument being standardized and reliable, its direct applicability across various contexts and subjects is not guaranteed. Therefore, it is imperative to reevaluate the instrument before each usage.

Conclusions

Based on the findings of the conducted research, it can be deduced that the development of a three-tier diagnostic test instrument for misconceptions evolved from formulating fundamental competency indicators to creating a question grid, resulting in a total of 40 test items. Following the progression through testing stages, including expert review, one-on-one, small group, and field tests, the test instrument yielded 24 items meeting the criteria for good-quality items, characterized by validity, reliability, and adept interpretation of difficulty and differentiation levels. The efficacy of the three-tier diagnostic test instrument in identifying student misconceptions and delineating student conceptual comprehension across three categories-conceptual understanding (26.65%), lack of understanding (26.96%), and misconceptions (47.20%) have been demonstrated.

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