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Construction and Standardization of an Achievement Test in Biology: A Study on Secondary Level Students in West Bengal

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Abstract

Assessment is a fundamental component of the educational process, serving not only to measure student learning but also to evaluate the effectiveness of instructional methods. This paper details the systematic construction and standardization of an achievement test in Biology designed for Class X students under the West Bengal Board of Secondary Education (W.B.B.S.E.). The study outlines the methodological steps involved in test construction, including the definition of instructional objectives based on Bloom's Taxonomy, the allocation of weightage to content and difficulty levels, and the development of a comprehensive blueprint. The resulting instrument is a 20-mark assessment comprising objective, short-answer, and essay-type questions aimed at measuring knowledge, understanding, application, and skill. The paper further presents a detailed question-wise analysis and scoring key, while establishing the content validity of the test through expert inspection to ensure conformity with instructional goals. This standardized tool provides a reliable mechanism for teachers to diagnose student strengths and weaknesses and facilitate remedial instruction.

Keywords

Achievement Test; Biology; West Bengal

1. Introduction

An achievement test evaluates the skills or knowledge a person has developed. The most common form is a standardized assessment created to measure what students have learned at a particular grade level through organized instruction, such as classroom teaching or formal training. In education, the results of achievement tests are often used to determine the level of instruction appropriate for each student. High achievement scores typically show that a learner has mastered the required material and is ready for more advanced work, while low achievement scores may indicate the need for additional support, remediation, or repeating certain content. To clarify the concept of an achievement test, several experts have defined it in the following ways:

- "Any test that measures the attainments and accomplishments of an individual after a period of training or learning" — N.M. Downie.
- "The type of ability test that describes what a person has learned to do" — Thorndike and Hagen.
- "A systematic procedure for determining the amount a student has learned through instructions" — Groulund.
- "An achievement of proficiency test is used to ascertain what and how much has been learnt or how well a task has been performed." — Super.
- "An achievement test is one designed to measure a student's grasp of some body of knowledge or

his proficiency in certain skills." — Robert L. Ebel.

- A test of educational achievement is a test "designed to measure knowledge, understanding, and skills in a specified subject or group of subjects." — Frank S. Freeman.

In summary, an achievement test serves as an effective way to determine the extent to which a student has progressed toward a specific educational goal.

1.1.Objectives of Achievement Test

The primary purpose of an achievement test is to use its results to determine whether students are ready to move on to more advanced levels of learning and to incorporate these results into educational planning. Beyond this main objective, achievement tests serve several additional important functions, including:

- Sorting students and placing them into suitable departments, tracks, or fields of study.
- Identifying strengths and weaknesses in all components of the educational process, which helps in creating effective plans to reinforce strong areas and address deficiencies.
- Assessing students' progress and determining whether the educational process is meeting its intended goals.
- Measuring the effectiveness of teaching methods and instructional programs, ensuring they achieve their aims and are appropriate for learners' developmental and cognitive levels.

2. Methodology

The research details the methodical process used to create and standardize an achievement test in Biology. This instrument, designed as a 20-mark assessment, was built upon a systematic plan that began with defining clear instructional goals using Bloom's Taxonomy. The methodology involved several crucial steps: developing a comprehensive blueprint; carefully distributing the total marks (weightage) across different subject content areas and various difficulty levels; the final test included a mix of question formats, specifically objective, short-answer, and essay-type questions and these questions were specifically designed to measure four key cognitive dimensions: knowledge, understanding, application, and skill.To ensure the test's quality and utility, the paper also provides a precise question-wise analysis and a detailed scoring key. Furthermore, the test's content validity was established through inspection by experts, confirming that the items aligned perfectly with the intended instructional objectives. Ultimately, this standardized tool offers educators a reliable way to accurately diagnose students' academic strengths and weaknesses, which in turn supports the implementation of effective remedial instruction.

3. Construction of Achievement Test

Planning is the initial and most crucial stage in developing an achievement test. Such a test requires thoughtful and systematic preparation. During the planning phase, the investigator must consider several key factors, including the subject area, the level of learners, the target group, the specific content to be measured, the timing of the assessment, and the methods of measurement. With these considerations in mind, the major steps involved in constructing an achievement test are as follows—

3.1.Planning of the test

The planning of the test was done according to various aspects such as age of the learner, class, previous knowledge, purpose of the test, identifying and defining the intended learning outcomes, subject matter included in the paper pencil test methods. The investigator planned the test considering the following steps:

Purpose: The biology achievement test was develop in accordance with two purpose namely, (a) the comprehensive study and utility of the experimental method for paper pencil and computer based examination, (b) to determine the effectiveness of the paper pencil tests method.

Target population: The target population comprised of science students of 10th class of W.B.B.S.E. based schools in West Bengal, where the facility to impart internet access is available.

Determine the maximum time and maximum marks: The maximum marks would be 20 and maximum time is 35 minutes.

3.2.Preparation of a Design for the Test

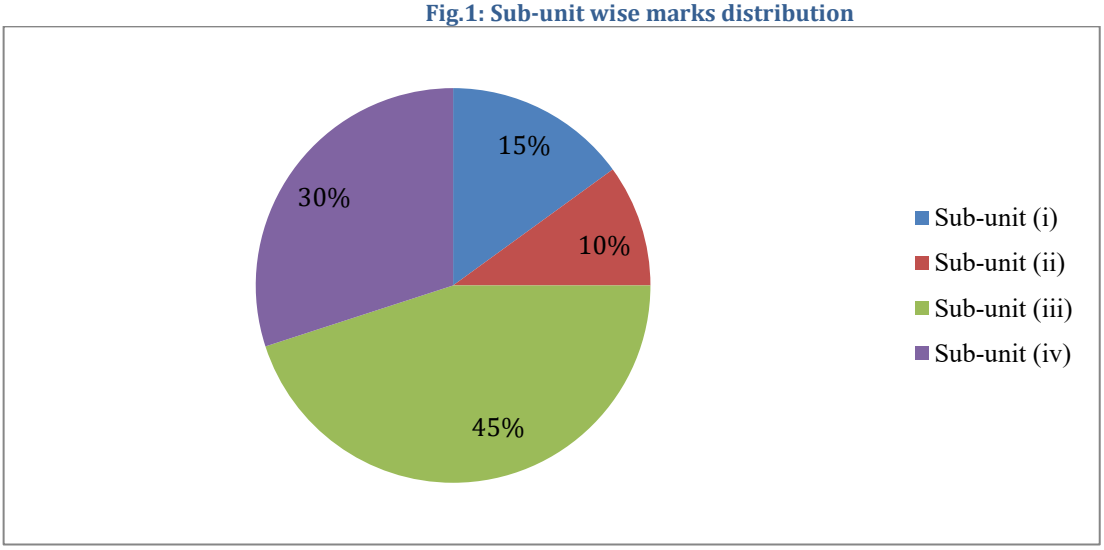
Important factors to be considered in design for the test are:

Weight age to content: The content of the test was chosen from 10th class biology students. Overall 12 chapters were selected from the 10th class book of biology. The final draft would have only selected 13 questions for paper pencil test. This indicates the various aspects of the content to be tested and the weight age to be given to these different aspects.

Table 1: Sub-unit wise marks distribution

Sl. No.	Sub-unit	Marks
1	(i)	3
2	(ii)	2
3	(iii)	9
4	(iv)	6
	Total	20

Fig.1: Sub-unit wise marks distribution



Weight age to objectives: The objectives of the biology achievement test were set in behavioural terms according to Bloom taxonomy of educational objectives. This indicates what objectives are to be tested and what weight age has to be given to each objective.

Table 2: Objective wise marks distribution

Sl. No.	Objective	Marks
1	Knowledge type questions (40%)	8
2	Understanding type questions (10%)	2
3	Application type questions (30%)	6
4	Skill type questions (20%)	4
	Total	20

Fig.2: Objective wise marks distribution

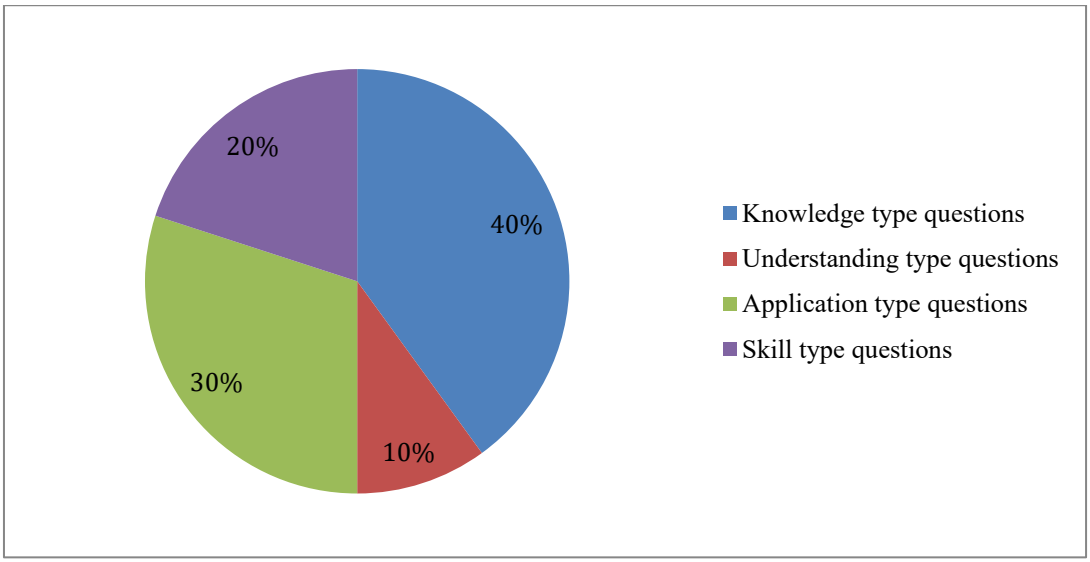


Table 3: Sub-unit wise distribution of objective along with marks

Sub-unit	Knowledge	Understanding	Application	Skill	Total
(i)	1	2	--	--	3
(ii)	--	--	2	--	2
(iii)	3	--	2	4	9
(iv)	4	--	2	--	6
Total	8	2	6	4	20

Weight age to form of questions: This indicates the form of the questions to be included in the test and the weight age to be given for each form of questions.

Table 4: Item wise marks distribution

Sl. No.	Type of Questions	Marks
1	Objective type questions	4
2	Very short type questions	4
3	Short type questions	8
4	Essay type questions	4
	Total	20

Fig.3: Item wise marks distribution

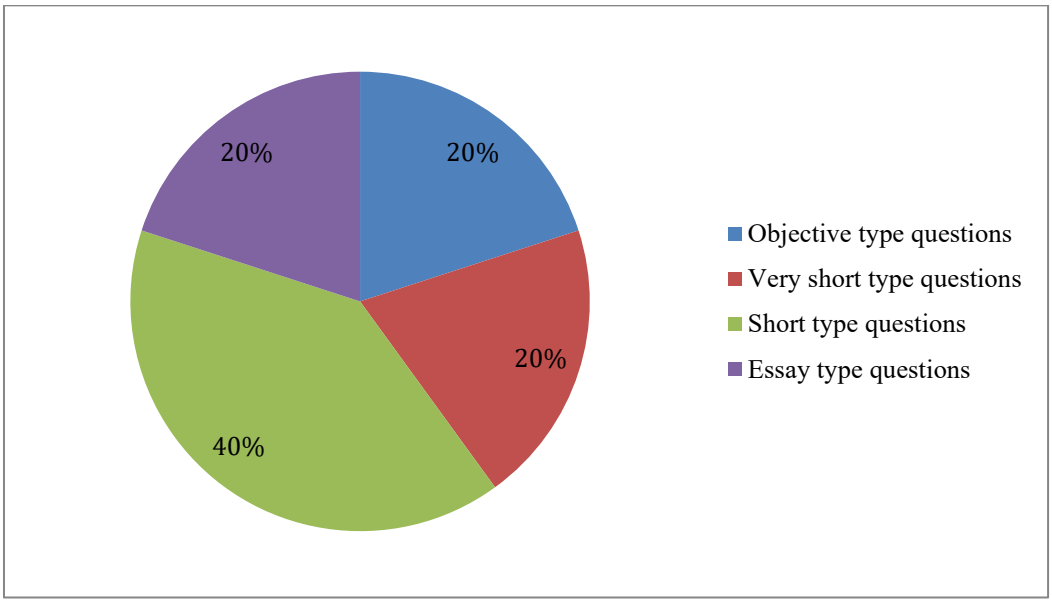


Table 5: Sub-unit wise distribution of type of questions item along with marks

Sub-unit	Objective	Very short	Short	Essay	Total
(i)	1	--	2	--	3
(ii)	--	--	2	--	2
(iii)	1	2	2	4	9
(iv)	2	2	2	--	6
Total	4	4	8	4	20

Weight age to the Difficulty Level: This indicates the difficulty level of the questions to be included in the test and the weight age to be given for each difficulty level of questions.

Table 6: Difficulty Level wise Marks Distribution

Sl. No.	Difficulty Level of Questions	Marks
1	Easy	9

2	Average	5
3	Difficult	6
	Total	20

Fig.4: Difficulty Level wise Marks Distribution

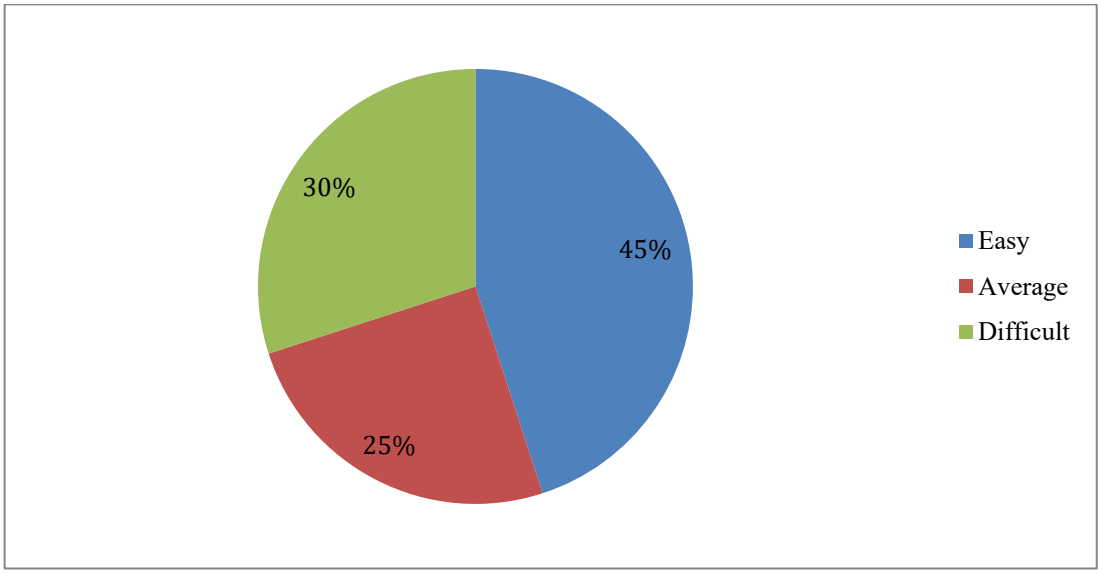


Table 7: Sub-unit wise distribution of difficulty level of questions item along with marks

Sub-unit	**Easy**	**Average**	**Difficult**	**Total**
(i)	--	1	--	1
(ii)	4	--	--	4
(iii)	2	4	4	10
(iv)	3	--	2	5
Total	9	5	6	20

3.3.Preparation of the blue print

Blue print is a three-dimensional chart giving the placement of the objectives, content and form of questions.

Subject: Biology
Time: 45 min.

Class: X
Full marks: 20

Objective	Knowledge type questions	Understanding type questions	Application type questions	Skill type questions	Total	%

Table 8: Blue Print

T:G / Sub-unit	Obj.	V.S.	S.	E.	Obj.	V.S.	S.	E.	Obj.	V.S.	S.	E.	Obj.	V.S.	S.	E.		
(i)	1 (1)						2 (1)										3 (2)	15
(ii)											2 (1)						2 (1)	10
(iii)	1 (1)	1 (1) 1 (1)									2 (1)					4 (1)	9 (5)	45
(iv)	1 (1) 1 (1)	1 (1) 1 (1)									2 (1)						6 (5)	30
Sub total	1 (4)	1 (4)					2 (1)				2 (3)					4 (1)	20 (13)	
Total	1 (8)				2 (1)				2 (3)				4 (1)				20 (13)	
Percentage	5				10				10				20					
Notes	Inside the ( ) mention the number of questions and figures outside the ( ) indicates the marks Obj.= Objective type V.S.= Very short type S.= Short type E.= Essay type																	

3.4.Writing of items

- The paper setter writes items according to the blue print.
- The difficulty level has to be considered while writing the items.
- It should also check whether all the questions included can be answered within the time allotted.
- It is advisable to arrange the questions in the order of their difficulty level.

Example:

Question Paper

Class: X **Time:** 45 Minutes
Subject: Biology **Total Marks:** 20

A) Objective Questions: 1×4=4

1) Choose the correct answer:
i) Hormone is (protein/fat). [Knowledge]
ii) Indole acetic acid is a (natural/synthetic) hormone. [Knowledge]
iii) Acromegaly is caused by excessive secretion of (growth/gonadotropin) hormones. [Knowledge]
iv) Source of estrogen hormone is (ovary/placenta) of female body. [Knowledge]

B) **Very Short Answer type Questions:** 1×4=4

1) From where insulin hormone is secreted? [Knowledge]
2) Name a non-nitrogenous plant hormone. [Knowledge]
3) Which hormone is used in seedless fruit production? [Knowledge]
4) Write the name of a mixed gland. [Knowledge]

C) Short Answer type Questions:2×4=8

1) Differentiate between enzyme and hormone. [Application]
2) Why hormones are called dual controllers? [Understanding]
3) Write the difference between endocrine and exocrine glands. [Application]
4) What changes can occur in the absence of gibberellin hormone in the plant body? [Application]

D) Essay type Questions: 4×1=4

1) Explain the phototropic movement of plants under effect of auxin with diagram. [Skill]

3.5.Preparation of Scoring Key and Marking Scheme

In the case of objective type items where the answers are in the form of some letters or other symbol a scoring key is prepared as follows—

Answer Sheet for Objective type Questions

Ques. No.	Answer	Marks
A.1.(i)	Protein	1
A.1.(ii)	Natural	1
A.1.(iii)	Growth	1
A.1.(iv)	Ovary	1

In the case of very short answer type items where the answers are in the form of some letters or other symbol a scoring key is prepared as follows—

Answer Sheet for Very Short Answer type Questions

Ques. No.	Answer	Marks
B.1.	Beta cells of islets of Langerhans in the pancreas	1

B.2.	Gibberellin	1
B.3.	Auxin	1
B.4.	Pancreas	1

In the case of short answer type items where the answers are in the form of some sentences a scoring key is prepared as follows—

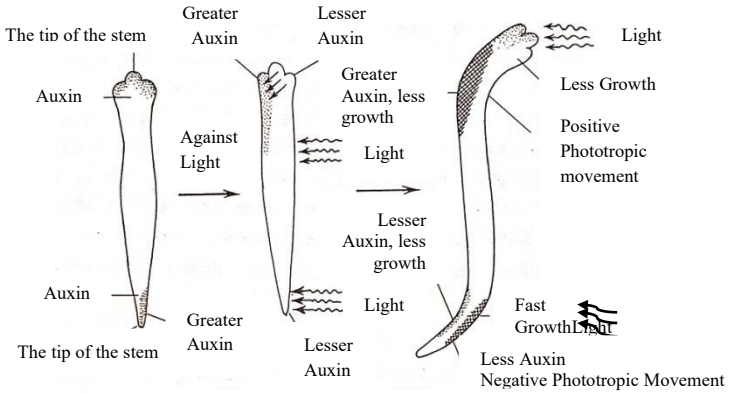
Answer Sheet for Short Answer type Questions

Ques. No.	Answer		Marks
C.1.	**Enzyme**	**Hormone**	2
	1. Enzymes are produced and function at their site of production. 2. External influences like temperature, pH levels, etc., significantly impact enzyme regulation	1. Hormones are produced and function at different sites. 2. External influences do not affect hormones as significantly as enzymes.	
C.2.	A hormone helps in some function in the animal body; another hormone prevents that action. Thus, hormones act as dual controller in the animal body.		2
C.3.	**Endocrine Glands**	**Exocrine Glands**	2
	1. Exocrine glands are the glands with ducts that allow the cells to secrete their products into those ducts so that they can be released onto the surface of the target cells or organs. 2. Exocrine glands monitor the short-term activities and functions of the target organs.	1. Endocrine glands are the glands that do not have a duct system and release their secretions or hormones directly into the bloodstream. 2. Endocrine glands control the overall structure, growth, and development of the target organs.	
C.4.	In the absence of gibberellins in the plant body, plants do not grow to sufficient length resulting in stunted plants. Flowers do not bloom in the plant body. Even if it blooms, its size is small. The seeds remain dormant. Leaves and fruits are small in shape.		2

In the case of essay type items where the answers are in the form of some sentences with one or more paragraphs a scoring key is prepared as follows—

Answer Sheet for Essay type Questions

Ques. No.	Answer	Marks

D.1.	Auxin plays a special role in controlling phototropic and geotropic movement of plants. Auxin is highly concentrated against the light source and causes rapid division of cells in that region, causing the plant stem to bend towards the light source. As plant roots are more sensitive to auxin, the cells on the side of the light source divide rapidly, causing the root to grow in the opposite direction to the light source.  **Phototropic Movement of Plant under the Effect of Auxin**	4

Marking Scheme:

In preparing marking scheme the examiner has to list out the value points to be credited and fix up the mark to be given to each value point.

Table 9: Marking Scheme

Ques. No.	Value Points	Marks	Total Marks
A.1.(i)	Value Point-1	1	4
A.1.(ii)	Value Point-2	1	
A.1.(iii)	Value Point-3	1	
A.1.(iv)	Value Point-4	1	
B.1.	Value Point-1	1	4
B.2.	Value Point-2	1	
B.3.	Value Point-3	1	
B.4.	Value Point-4	1	
C.1.	Value Point-1	2	8
C.2.	Value Point-2	2	
C.3.	Value Point-3	2	
C.4.	Value Point-4	2	
D.1.	Value Point-1	4	4

3.6.Preparation of Question-wise Analysis

It helps to know the strengths and weakness of the test, to tally the question paper and the blueprint, and to determine the content validity of the test.

Table 10: Question-wise Analysis

Ques. No.	Content	Objectives	Form of Questions	Difficulty Level	Marks	Estimated Time (in min.)
A.1.(i)	Sub unit-(i)	Knowledge	Objective type	Average	1	1
A.1.(ii)	Sub unit-(iii)	Knowledge	Objective type	Average	1	1
A.1.(iii)	Sub unit-(iv)	Knowledge	Objective type	Easy	1	1
A.1.(iv)	Sub unit-(iv)	Knowledge	Objective type	Easy	1	1
B.1.	Sub unit-(iv)	Knowledge	Very Short Answer	Easy	1	2
B.2.	Sub unit-(iii)	Knowledge	Very Short Answer	Easy	1	1
B.3.	Sub unit-(iii)	Knowledge	Very Short Answer	Average	1	2
B.4.	Sub unit-(iii)	Knowledge	Very Short Answer	Easy	1	1
C.1.	Sub unit-(ii)	Application	Short Answer	Easy	2	5
C.2.	Sub unit-(ii)	Understanding	Short Answer	Easy	2	2
C.3.	Sub unit-(iv)	Application	Short Answer	Difficult	2	5
C.4.	Sub unit-(iii)	Application	Short Answer	Average	2	3
D.1.	Sub t unit-(iii)	Skill	Essay type	Difficult	4	10

4. Standardization of Achievement Test

20 items constituted of achievement test. Achievement test was further standardized by reliability and validity.

4.1.Reliability

The reliability of a measuring instrument is the degree of consistency with which it measures whatever it was measuring. A test must be reliable that it must have the ability to consistency yield the same result when repeated.

4.2.Validity

Validity is the most important aspect of a test which can define as the degree to which a test is capable of measuring the achievements for which it is designed. There are different methods of estimating validity such as face validity, content validity, construct validity, predictive validity and concurrent validity.

In this study, the biology achievement test was evaluated for content validity. Subject experts carefully reviewed the entire test and judged whether each item appropriately corresponded to the specified

content areas. The test content was then examined in relation to the instructional objectives. Because the test items aligned well with the table of specifications, the biology achievement test was determined to have strong content validity. To assess construct validity, the investigator ensured that the selected content was organized logically and sequentially, matching the learners' age and educational level. As a result, the biology achievement test met the requirements for establishing construct validity.

5. Conclusion

The teaching–learning process loses its purpose without evaluation, making effective assessment tools essential in any educational setting. Among these tools, achievement tests play a key role. Item analysis helps determine whether test items are easy, difficult, or of moderate difficulty, thereby providing the difficulty index for each item. It also reveals why certain items may not be functioning well and how they can be improved. Item discrimination, on the other hand, shows whether students who performed well on the overall test also performed well on specific items. Ideally, each item should distinguish clearly between high- and low-scoring students.

The present work focused on constructing a reliable and valid achievement test in life science. This test can be used by teachers to assess students' achievement in biology after they have completed the relevant Class X content. Given the scarcity of such tools during this unprecedented period, the achievement test developed here will be valuable for biology teachers in evaluating students' learning in alignment with the context and different levels of instructional objectives.

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