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Construction and Standardization of an Attainment Test in Physics for Class-VIII Students

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Abstract

The subject Physics focuses on conceptual learning. Students who have a strong foundation in basic physics concepts can connect new material to what they already know, leading to deeper understanding and more effective learning. From Several research studies it was revealed that there is a significant positive correlation between prior knowledge and the learning outcomes in the subject Physics. Students with higher prior knowledge perform better in assessments and feel more comfortable during the learning process. Therefore, constructing a prior knowledge test in physics which is also known as an Attainment test is a critical step in effective science education. It provides an important diagnostic information, supports personalized learning, and finally leads to better outcomes of the students and a more meaningful understanding of the concepts of physics. Therefore, construction and standardization of an Attainment Test is a basic tool in understanding the prior knowledge of the students. The present study targeted to construct and standardize Attainment test in Physics for school students studying in Class-VIII. The test consists of Multiple-Choice Test items with four options where one option is correct and other three are wrong. The test was constructed in Assamese (vernacular) and English language. For constructing the Attainment Test, 50 test-items was selected from the 100 test-items after item analysis. A sample of 667 students was selected purposively from the eleven schools. To evaluate the test's validity and reliability, the collected data were studied using the Pearson Product Moment correlation method to determine the reliability coefficient. The reliability coefficient of the English version of the test was found as 0.67, while it was recorded as 0.82 for the Assamese version (vernacular language). The reliability coefficient of the test was recorded as 0.75 while calculated for both the language English and Assamese (vernacular) jointly. Present study revealed that the constructed Attainment test was found to be quite satisfactory, which can be used as an assessment tool for determining the prior knowledge of Class-VIII students in Physics.

Keywords: Attainment test, Prior Knowledge, Construction, Standardization, Physics.

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1.0 Introduction

Physics is an important branch of science consisted of many theories and concepts that describe the fundamental process of nature. Every aspect of our lives is dominated by the fundamental ideas and theories of Physics.

Therefore, understanding the basic concept of the subject at the school level is an essential part of any learning process. It is argue by many researchers that from the school level, students must be able to hold the basics of Physics in addition to knowing the subject matter as facts, concepts, or principles (Frost & Turner 2005; Tajudin & Chinnappan 2016). Students with a strong foundation in basic physics concepts can connect new material to what they already know, leading to deeper understanding and more efficient learning (Gjerde et al. 2021). When students encounter new situations or problems, they often draw on descriptive, hypothetical, or theoretical concepts learned previously, helping them apply physics knowledge in novel contexts (McBride et al. 2010). Accurate prior knowledge supports learning, but misconceptions or flawed ideas can hinder understanding (Delahay et al. 2023). Physics educators must identify and address incorrect beliefs to prevent them from interfering with new learning. From various research studies it was revealed that there is a significant positive correlation between prior knowledge and physics learning outcomes. Students with higher initial understanding perform better in assessments and feel more comfortable during the learning process (Gonzalez, 2022). Teachers should assess students' existing knowledge before introducing new physics topics to tailor instruction and address gaps or misconceptions. Effective physics instruction connects new material to students' prior experiences and understanding, helping them construct more sophisticated scientific models and explanations. Physics based learning process enhanced the mental and physical activity (Ates & Eryilmaz 2011). Hence, a systematic evaluation of these concepts among students is important step for science teaching and learning. The evaluation of student ability is done mainly by verbal and written assessment (Apino & Retnawati 2017). The written assessments can be measured by a test, which is an assessment tool or standard procedure used to intelligence level by posing a set of questions (Dickson *et al*. 2020). An ideal test construction required several detailed steps (Eze *et al*. 2017). Researcher who is engaged in the test development activity, one needs to start with constructing the variables. Thus, the constructed test is required to standardize. A test with standard administration, scoring, and interpretation practices is known as a standardized test. The standardized tests constructed by the researchers are standardized in terms of how they were scored and administered under consistent, standardized testing environments, allowing the findings from various samples to be properly compared (Mana & Mete 2021). The quality of a test depends on the quality of the prescribed curriculum.

To ensure the quality of a test, evidence of validity and reliability are required (Kimberlin & Winterstein 2008). The consistency of the test is referred to as reliability, whereas the truthfulness of findings is referred to as validity (Mohajan, 2017). A test is said to be valid if it is capable of retaining what is being tested (Facione et al. 2000). Types of validity include content or curricular validity, criterion-related validity, and construct validity. For the present study, the researcher used content validity. By analysing the contents of each test item individually as well as together, the content validity was estimated. This method is used for measuring educational performance and proficiency (Singh 2015).

The reliability of a test refers to the consistency of the score or measurement which is reflected in the reproducibility of the scores (Singh 2015). Reliability is the degree to which a measurement instrument produces consistent results when tested and re-tested as well as the degree to which a test is internally consistent. Test-Retest reliability (temporal stability) over time, internal consistency among items, and inter-rater reliability among different researchers are the three types of consistency (Heale & Twycross 2015).

The Test-Retest technique for determining reliability has been considered by the researcher to be suitable for the study. In this technique, a test is administered twice to the same group under the same conditions. The reliability coefficient can be estimated by correlating the two sets of scores from the same test. Pearson Product Moment correlation is used to estimate the reliability of the tests. The value of the reliability coefficient should be between 0.00 and 1.00 and should not have a negative value. The value of reliability coefficient 0.70 is considered satisfying (Fraenkel *et al*. 2012).

As Physics is consisted of many theories and concepts that describe the fundamental process of nature. Therefore, understanding the basic concept of the subject at the school level, prior knowledge is essential. Thus, considering the nature and characteristics of Physics, there is a need to know the level of Attainment in Physics among the school students. Therefore, this study is an attempt to construct and standardize a multiple-choice Attainment test in Physics for Class-VIII students. Attainment test is a test that measures the learner's achievement against a set of specified learning objectives in order to assess how much they have learned (Wallace 2015).

2.0 Method

In accordance with the objective of the study, i.e., to Construct and Standardize an Attainment Test in Physics for the Class-VIII students. The following sub-objectives are followed-

2.1 To prepare a draft of the Attainment Test in Physics for Class-VIII students.

2.2 To try out the draft of the Attainment Test in Physics for Class-VIII students.

2.3 To make item analysis of the draft of the Attainment Test in Physics for Class-VIII students.

2.4 To make selection of test-items for final draft of the Attainment Test in Physics for Class-VIII students.

2.5 To determine the validity of the Scientific Reasoning Test in Physics.

2.6 To determine the reliability of the Scientific Reasoning Test in Physics.

To construct and standardize Attainment Test in Physics for the Class-VIII students the researcher used the following steps—

1. Planning of the test
2. Preparation of the test
3. Administration of the test
4. Item analysis
5. Standardization of the test.

The steps of construction and standardization of Attainment Test in Physics for the Class-VIII students has been shown in the following Fig 1.

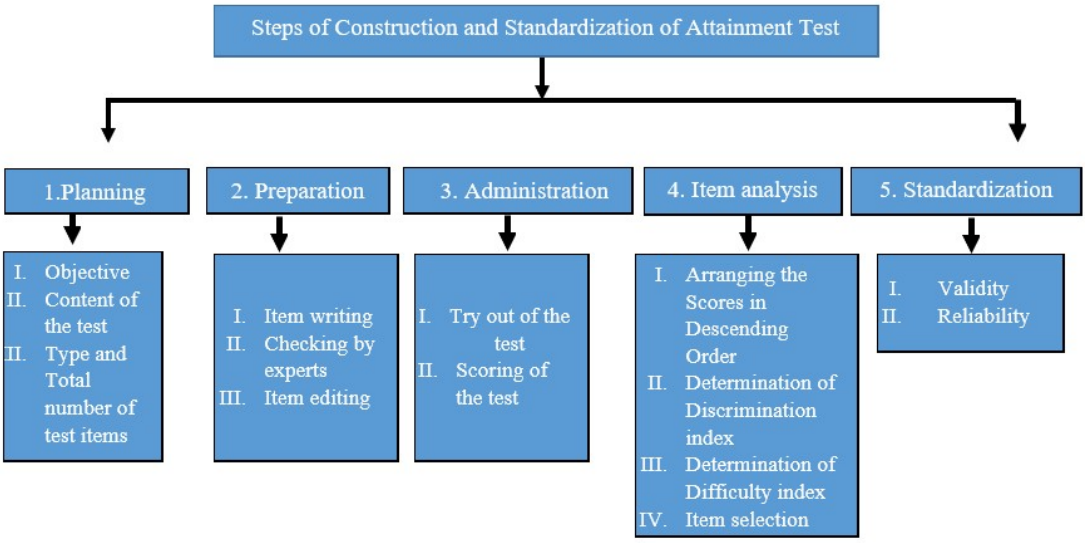

Fig 1: Steps of construction and standardization of the Attainment Test in Physics

To construct and standardize the Attainment Test in Physics for the Class-VIII students, the researcher followed the following steps-

1. **Planning of the test:**

A test for Attainment in Physics was constructed and standardized by the researcher to measure the Attainment in Physics of the Class-VIII students. The test was a multiple-choice test, based on the selected contents from the Science textbooks of Class-VI and Class-VII prescribed by NCERT (National Council of Educational Research and Training) (Uppal 2006; Uppal 2007). Each item has four options. There are 16 chapters in the Science textbook of Class-VI from which 6 chapters of Physics were taken and also from the Science textbook of Class-VII, out of 18 chapters, the researcher took 6 chapters of Physics. The Chapters of Physics from NCERT (National Council of Educational Research and Training) Science textbooks are shown Table 1.

Table 1: Chapters from the Science textbooks of Class-VI and Class-VII

Sl. No.	**Chapters from the Science textbook of Class-VI**	**Chapters from the Science textbook of Class-VII**
1.	Motion and measurement of distances	Motion and Time
2.	Light, shadows, and reflections	Electric Current and its Effects
3.	Electricity and circuits	Light
4.	Fun with magnets	Heat
5.	Water	Physical and Chemical Changes
6.	Air around us	Winds, Storms and Cyclones

The test items were constructed in both Assamese and English language. A response sheet was prepared which provided space for students to fill in details such as their name, class, school, date, and their response to each item. Student's answers to each item were considered correct only when they provided the correct choice for each item. The Weightage allotted to the domain of the Attainment Test in Physics is shown in Table 2.

Table 2: Weightage Allotted to the domain of Attainment Test in Physics.

Sl. No.	Domain	Number of items	Percentage (%) of Number of test items
1.	Knowledge	10	20
2.	Comprehension	15	30
3.	Application	25	50
Total		**50**	**100**

***Application includes application, analysis, synthesis, and evaluation of Bloom's Model (Rajput et al., 2002).**

The blueprint of the Attainment Test in Physics for the Class-VIII students is shown in Table 3.

Table 3: Blueprint of the Attainment Test in Physics

Sl. No.	Chapter	Knowledge (No. of items)	Comprehension (No. of items)	Application (No. of items)	Total
1.	Motion and measurement of distances	1	2	5	8
2.	Light, shadow, and reflection	1	1	4	6
3.	Electricity and circuits	1	1	3	5
4	Fun with magnets	1	1	2	4
5	water	1	1	0	2
6	Air around us	1	1	0	2
7	Motion and time	0	2	3	5
8	Electric current and its effect	1	1	1	3
9	Light	1	1	4	6
10	Heat	0	2	2	4
11	Physical and chemical changes	1	1	1	3
12	Winds, storms, and cyclone	1	1	0	2
Total		**10**	**15**	**25**	**50**

2. Preparation of the test:

The researcher constructed pool of items for the present study. Items for constructing the test were collected through critical study of the available literature on Achievement Tests in Physics from books, available Research papers and in consultation with experts. The reference books of Science for Class-VI and Class-VII were also read for this purpose. This helped the researcher in the preparation of the draft of the Attainment Test in Physics. In the draft of the Attainment Test in Physics, the researcher wrote more numbers of items from which items for the Final test were selected. The number of test items prepared from each chapter of Physics from the Science textbooks of Class-VI and Class-VII are shown in Table 4.

Table 4: Chapters and number of test items prepared for the Attainment Test in Physics.

Sl. No.		**Chapters**	**No. of Test items**
1.	**Chapters from Science textbook of Class-VI**	Motion and measurement of distances	12
2.		Light, shadows, and reflections	7
3.		Electricity and circuits	10
4.		Fun with magnets	8
5.		Water	2
6.		Air around us	3
7	**Chapters from Science textbook of Class-VII**	Motion and Time	19
8		Electric Current and its Effects	8
9		Light	16
10		Heat	6
11		Physical and Chemical Changes	5
12		Winds, Storms and Cyclones	4
Total			**100**

After writing the test items, the researcher consulted with the supervisor and subject experts to check the content coverage according to the blue print or any modification required in the items of the test. The necessary modifications were done on a few test items as per the suggestions given by the experts. The blueprint of the test items of the Attainment Test in Physics for the Class-VIII students is shown in Table 5.

Table 5: Blueprint of the Attainment Test in Physics.

Sl. No.	Chapter	Knowledge (Sl. No. of test items)	Comprehension (Sl. No. of test items)	Application (Sl. No. of test items)	Total
1.	Motion and measurement of distances	1,3	2,5	6,7,12,13, 89,90,99,100	12
2.	Light, shadow, and reflection	15	16,17,18,19,21	20	7
3.	Electricity and circuits	25,26,74	29,31,75	86,87,88,92	10
4	Fun with magnets	33	32,34	35,36,37,38,39	8
5	water	42	40	----------	2
6	Air around us	43,44	41	----------	3
7	Motion and time	----------	4,10,48,98	8,9,11,14,47,49,50,51,52, 53,54,84,85,91,94	19
8	Electric current and its effect	27,28	30,58	55,56,57,59	8
9	Light	60,61,62,67	63,64,65,66	22,23,24,68,69,70,71,97	16
10	Heat	---------	72,73,95	76,93,96	6
11	Physical and chemical changes	46	77,79	45,78	5
12	Winds, storms, and cyclone	80, 81,82	83	----------	4
Total		20	30	50	100

In the preparation for the Attainment Test some Chapters do have not such content from which Application-level questions should be framed.

3. Administration of the test

For administering the Attainment Test and try-out of the draft of the Attainment Test in Physics six schools of the Charaideo district, were selected using a purposive sampling method. The test was administered to a group comprising 304 students studying in Class-VIII in the Schools.

a) **Instruction:** Necessary instructions for respondents were prepared and added to the front page of the draft test. Oral instructions were also given whenever necessary.

b) Scoring Procedure: The process of scoring the test is shown in Table 6.

Table 6: Scoring of the Attainment Test.

Sl.No.	ANSWER	MARKS
1.	Correct	1
2.	Incorrect	0

4. Item Analysis:

After scoring of the test, the researcher arranged the scores of all the sampled 304 students in descending order, i.e., from the highest to the lowest score. Based on the total score, the upper 27% of the examinees from the top scorer and the lower 27% of the examinees from the bottom scorer were separated to form two separate groups namely, the high group and the low group. Then, the discrimination index (V) and difficulty index (P) for each test item were calculated to find out whether the discrimination index and difficulty index of a particular test item was significant or not. Items with a discrimination index of more than 0.36 (Ebel & Frisbie 1991) and difficulty index between 0.36 to 0.70 (Ebel & Frisbie, 1991) were kept for the calculation of reliability. Out of 100 test items, 58 test items had significant discrimination index and difficulty index. The distribution of the test items having satisfactory discrimination index and difficulty index are shown in Table 7.

Table 7: Distribution of the test items having satisfactory discrimination index and difficulty index.

Sl. No.	**Chapter**	**Knowledge** (Sl. No. of test items)	**Comprehension** (Sl. No. of test items)	**Application** (Sl. No. of test items)	**Total No. of test items**
1.	Motion and measurement of distances	3	5	6,7, 89,99,100	7
2.	Light, shadow, and reflection	15	16,17,18,19, 21	---	6
3.	Electricity and circuits	25,26	29,31,75	86,88	7
4	Fun with magnets	33	32,34	35,37	5
5	water	--------	40	----------	1
6	Air around us	43,44	41	----------	3
7	Motion and time	----------	4,10,48,98	9,14,50,53,54, 84,91,94	12
8	Electric current and its effect	28	30	----------	2
9	Light	67	63,66	22,23,70,71,97	8
10	Heat	---------	73	93,96	3
11	Physical and chemical changes	--------	77	79	2
12	Winds, storms, and cyclone	80	83	----------	2
Total		**10**	**23**	**25**	**58**

The researcher decided to include 50 test items having a higher discrimination index from the 58 test items having a satisfactory discrimination index and difficulty index. The researcher also considered the number of test items in each domain for the final draft of the Attainment Test in Physics for the Class-VIII students while selecting the items for the final test. The distribution of the 50 test items in each domain for the final draft of the Attainment Test in Physics for the Class-VIII students is shown in Table 8.

Table 8: Test items for the final draft of the Attainment Test in Physics

Domain	Sl. No. of test items	Total No. of Test-items	Percentage(%) of No. of Test-items
Knowledge	3,15,25,26,28,33,43,44,67,80	10	20
Comprehension	5,17,18,21,29,30, 34,40,41,48,63,73,77,83,98	15	30
Application	6,7,9,14,22,23,35,37,50,53,54,70,71, 79,84,86,88,89,91,93,94,96,97,99, 100	25	50
Total		**50**	**100**

5. Standardization of the test:

5.1. *Validity of the test*

To determine the content validity, the draft Attainment Test was sent to a number of experts to check the coverage of contents and also check whether the blue print covers all the contents of the test. Based on their suggestions necessary modifications were done in preparing the different test items of the test.

5.2. *Reliability of the test*

The Test-Retest technique was used to estimate the reliability of the Attainment Test in Physics. To test the reliability, the Attainment Test in Physics was administered twice to a group comprising 363 students studying in Class-VIII in the selected schools. Two sets of scores were obtained from these tests. Then the Pearson Product-Moment Correlation was used to calculate the reliability coefficient. The reliability coefficient of the English version of the test was found as 0.67. The reliability coefficient of the Assamese translated version of the test was found as 0.82. Again, when the scores of the English version and the Assamese translated version of the tests were calculated together, then the reliability coefficient of the test was found as 0.75.

3.0 Results and Discussions:

The discussion is based on the main findings of the research questions. To ensure the quality of the test, evidence of validity and reliability are required (Kimberlin & Winterstein 2008). A test is said to be valid if it is capable of retaining what is being tested (Facione *et al*. 2000). For the present study, the researcher used content validity. By analyzing the contents of each test item individually as well as together, the content validity was estimated. This method is used for measuring educational performance and proficiency (Singh 2015). To ensure the content validity of the Scientific Reasoning test in Physics expert judgement was employed.

The reliability of a test refers to the consistency of the score or measurement which is reflected in the reproducibility of the scores (Singh 2015). Reliability is the degree to which a measurement instrument produces consistent results when tested and re-tested as well as the degree to which a test is internally consistent.

The Test-Retest technique for determining reliability has been considered by the researcher to be suitable for the study. In this technique, a test is administered twice to the same group under the same conditions. The reliability coefficient can be estimated by correlating the two sets of scores from the same test. Pearson Product Moment correlation is used to estimate the reliability of the tests. The value of the reliability coefficient should be between 0.00 and 1.00 and should not have a negative value. The value of reliability coefficient 0.70 is considered satisfying (Fraenkel *et al*. 2012). The researcher used the Pearson Product Moment formula, to find

the reliability coefficient of the test. The researcher consulted different existing Achievement Tests for the construction of the Attainment Tests in Physics for the present study. Attainment Test which is also a type of Achievement Test that measures the prior knowledge. Therefore, the researcher consulted the available Achievement tests for the purpose of the construction of Attainment Test in Physics. Previous studies by Bhagat and Baliya (2016), Khan (2023), Kumari & Mane (2023), Mana & Mete (2021) and Sharma and Sansanwal (2018) have also employed test-retest technique to estimate the reliability of the Achievement test in Science.The reliability coefficient of the English version of the test was found as 0.67. The reliability coefficient of the Assamese-translated version of the test was found as 0.82. Again, when the scores of the English version and the Assamese translated version of the tests were calculated together, then the reliability coefficient of the test was found as 0.75.In comparison, Bhagat & Baliya (2016) reported reliability co-efficient 0.82, Khan (2023) reported reliability co-efficient 0.91, Kumari & Mane (2023) reported reliability co-efficient 0.87, Mana & Mete (2021) reported reliability co-efficient 0.84 and Sharma and Sansanwal (2018) reported reliability co-efficient 0.84 using the test retest technique for estimating the reliability. This study has found out that this Attainment test has a significant reliability of 0.75 which is nearly equal to the above reported ones. The items in the A test were selected through the item analysis. Their discrimination index (V) and difficulty index (P) were computed. Items with a discrimination index of more than 0.36 (Ebel & Frisbie 1991) were kept for the calculation of reliability. Items with a difficulty index between 0.36 to 0.70 (Ebel & Frisbie 1991) were kept for the calculation of reliability. Out of 100 test items, 50 test items had significant discrimination index and difficulty index. All items in the instrument are within the range of 0.36 and 0.70 making them very appropriate, suitable and effective.

In conclusion, the Attainment test constructed by the researcher contains items that are suitable and appropriate in terms of difficulty and discrimination indices, with satisfactory reliability and validity established.

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