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Development of a test for assessing students' academic performance in mathematics

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Abstract: *The purpose of this study was to develop an academic achievement test in mathematics for 9th-grade students. The research development method was used for the construction of the test. A sample of 100 students was selected randomly from the government schools of Chandigarh. Most of the available assessments tests were memory-based and subjective. That's why the test related to concepts taught in ninth class was made considering real-world phenomena and situations. Content validity was used for validation of the assessment instrument. The result showed that the test was validly stated with the reliability coefficient 0.89. Hence, a test is developed that encouraged students' understanding of the concepts, strategies and decision in dealing with mathematics problems.*

Key Words: *Academic performance, academic performance in mathematics, achievement in mathematics.*

1. INTRODUCTION:

Human civilization is developed by continuously expanding its knowledge and by improving its skills. A variety of aspects contribute to this improvement. If one remains a relentless interrogator demanding to know the When, What, Who, Where, and Why of life, the shape of knowledge keeps constantly changing. Once the knowledge is acquired, its assessment is very crucial. An evaluation helps in monitoring students' progress which is assessed through different types of achievement tests. It is an essential aspect of teaching-learning as it is a measure of knowledge, understanding and skills in a specified subject or group of subjects (Craighead, & Charles, 2004). Schools utilize these scores to measure different aspects of teaching-learning.

The fundamental purpose of achievement testing is to promote learning (Flateby,1996) . In India, where only reading, writing, and arithmetic ability are indicators of a student's level of learning (Herald, Philip, Sharma, & Ganguly, 2017) and mathematic ability is assessed based on formula grasping and the ability to put bits of information into the formula. This has drowned us in the state of affairs where "Over one-third engineers do not possess mathematical skills needed in day-to-day life for doing simple transactions, counting and arranging. They have a weak understanding of concepts as elementary as decimals, powers, operations, ratio, fractions and the ability to apply these concepts to real-world problems" (India Today, 2012). In 2008, 37% of class V students could do basic maths, and in 2019 only 29% of class V students were able to do basic maths (Chettri, & Ibrar, 2019). In classrooms, students are assessed based on answers to questions that are similar to the textbook, which only encourages the mechanical process. An appropriate assessment in mathematics can guide the actual scenario of students' understanding.

2. ACHIEVEMENT IN MATHEMATICS:

Every human effort is always directed towards a specific goal. A series of efforts are checked from time to time to ascertain whether efforts are in the right direction or not. In school life, examinations play a similar role for students, teachers as well as school authorities. The achievement test is used to measure the effect of specific teaching or training given to a student (Craighead, & Charles, 2004) to measure the level of acquired learning and for remediation etc. The fundamental assumption of psychology says there are changes within the individual from time to time known as behaviour oscillation, i.e. achievement of the same individual may differ from time to time, from one class to another and from one educational level to another. It further adds that there are individual differences. Individuals of the same age group of the same grade usually differ in their potential abilities, academic proficiency, whether these are measured by standardized measures of achievement by teacher's grading or by marks obtained in tests and examinations (Dewan, 2003). There is a need to assess these differences in education to guide students toward the right goal. Achievement test results should accurately measure individual differences on pre-specified mastery level (Flateby, 1996).

With the growing advancement in science and technology, mathematics has become so crucial that every parent today sets high goals for the students to achieve(Kaur, 2013). Students incline towards mugging up some chunks in the form of formula or concept. Mathematics is a subject that is not limited to specific skills or facts which can be remembered or acquired through mechanical rote learning. Mathematic learning requires activities that involve in-depth and meaningful learning of intellectual structures. Knowledge of mathematics is used in real-life situations practically. That's why; assessment of students' knowledge in mathematics can not be ignored. Achievement in mathematics is

viewed basically as the competence a person has in an area of mathematical content. Achievement test in mathematics should assess content as well as process skills like intra-connection and interconnection between concepts of mathematics.

3. ASSESSMENT INSTRUMENT:

As per Harlen (2007), "Assessment is the process of collecting, interpreting and using evidence to make decisions about students' achievement in education". In this study, a test for assessing students' performance in mathematics for IX graders 13-16 years of age was developed to improve learning in the classroom. Most achievement tests were memory-based, and the answer can be given in a mechanical manner. An objective test related to content includes a vast portion of the concept and can not be answered by rote memory. That's why an objective achievement test was made. The test can be used as an assessment to plan lessons, recognize student needs in learning and re-teach concepts which are not understood by students.

4. METHODOLOGY:

The research and development model by Borg and Gall was selected for test preparation. The researcher took just three steps in this research, and the process was adapted to the needs of development. The conceptual framework was obtained through a review of related literature and preliminary draft based on topics, i.e. Linear equation in two variables, surface area and volume, statistics and probability consisted of 70 items was reviewed by ten experts for content validity. The test was assessed on a sample of 100 students of the IXth standard of Chandigarh who has studied the concepts.

4.1 Planning:

In research, gathering the information is the crucial step in planning for a problem that is studied and to fetch the idea of the product to be developed. A necessary analysis was performed. The literature review was conducted by reviewing several books and relevant research results. The researcher went through the literature on achievement tests in mathematics, and discussion was also held with subject teachers of the school, teacher educators and experts in the field of education to seek their view to plan appropriate achievement test in mathematics for IX graders with 13-16 years of age.

Test items were prepared on linear equation in two variables, surface area and volume, statistics and probability topics in mathematics. For testing instructional objectives, the researcher prepared a blueprint of achievement test in mathematics comprising multiple-choice test items, fill in the blanks and match the item's type. The researcher framed items based on knowledge, understanding, application, analysis, synthesis and evaluation objectives according to Bloom's taxonomy of educational objectives (as cited in Adams, 2015) on selected topics of ninth standard mathematics content. A total of seventy questions on selected content based on Bloom's taxonomy were prepared to assess students' acquisition of content knowledge. The numbers of items were made according to the weightage of the topic.

Table 1.1 Blueprint of the first draft of achievement in mathematics test

S. No.	Unit	Knowledge			Understanding			application			Analysis			Synthesis			Evaluation			Total
		F	MC	M	F	MC	M	F	MC	M	F	MC	M	F	MC	M	F	MC	M	
1	Linear equation in two variables	1			1	2	3		1			1						3	1	13
2	Surface area and volume	1	1			2		2	3			2		2	2		1	1		17
3	Statistics	2	3			4		1	4		3	3						3		23
4	Probability	1		2	1	2	2		2		3			1	2			1		17

Here F signifies fill in the blank; MC signifies multiple-choice, and M signifies the matching type

4.2 Testing the instrument:

An initial draft was given to ten professionals for content validity. Concise information of the concept area was given to professionals along with the first draft for their remarks. Expert opinion was taken from competent school teachers, proficient assistant professors and professors of Chandigarh. After professional review, five items were modified, five items were removed. A modified draft of 65 items was used for a tryout.

The test of 65 items was given to a small sample of 15 students of the CBSE school of Chandigarh. These students were comparable to the sample of the researcher's present research. The main aim was to assess the difficulty level and complexity of test items. Some ambiguous and complex sentences were modified, and the test was made in all other aspects according to students' level. Instructions for students were given on the cover page. One mark was decided for each correct mark.

Further, the test was assessed on a sample of 100 students of government schools in Chandigarh. Kelley (1939) method opted for item analysis. Sixteen items having discriminating power 0.19 and below were eliminated. In the context of difficulty value, fifty-two items were good items. Two items had difficulty value more than 0.67, and ten items were less than 0.20 were eliminated. Four items had a negative discrimination index which indicates the most well-informed examinees are getting the item wrong and the least knowledgeable examinees are getting the item right. So these items were removed. The final draft contained 48 items, and only three items of dimension synthesis were selected. So, it was clubbed with the analysis dimension for further testing of the tool.

Table 1.2 Blueprint of the final draft of achievement in mathematics test

S. No.	Unit	Knowledge			understanding			Application			Analysis/synthesis			Evaluation		
1	Linear equation in two variables	F	MC	M	F	MC	M	F	MC	M	F	MC	M	F	MC	M
		1			1				1			1			3	
2	Surface area and volume	1	1			1			2			3			1	
3	Statistics	1	3			2		1	3		3	3			3	
4	Probability	1		2	1	1	2		2		2	1			1	
		4	4	2	2	4	2	1	8		5	8			8	
		10			8			9			13			8		

Here F signifies fill in the blank; MC signifies multiple-choice, and M signifies the matching type

4.3 Reliability and Validity:

The final form of the achievement test was administered to 100 students of government schools in Chandigarh. The test was scored and tabulated to find out the reliability. The reliability coefficient of KR-20 for the achievement test was found to be .932 for 48 items. The test-retest correlation coefficient was found to be .89 ($N=100$, $p<.01$). Hence the test was considered as reliable.

Content validity was done by ten subject experts. For internal validity, dimension wise correlation was assessed. The values of the coefficient of correlation between inter subscales with total scale were calculated by Pearson's product-moment coefficient. The inter-dimension coefficient of correlation was found to be between 0.64 and 0.88. The coefficient of correlation between dimensions and total test scores ranges between 0.78 and 0.90, which shows that each dimension is an integral part of the total test. This establishes the validity of the test.

4.4 Objectivity and Practicability:

A test should be objective in scoring and administration. Personal opinion, interests and attitudes of the examinee and the examiner should not affect test scores. There should be a clear and precise scoring rule for each item. Here each question has a definite answer, and one score is given for each right answer and zero scores for each wrong answer.

The practicability of the test lies in the administration of a test. Achievement test in mathematics is easy to administer and inexpensive. It took 45 minutes to administer. The present test is practical in the sense that it is not expensive in term of its administration. The test can be administered individually or in small groups.

5. RESULT:

Mathematics requires skills like understanding of the relationships among patterns and principles of mathematics, reflective judgment, conceptual understanding, and content mastery (Raudenbush, Rowan, & Cheong, 1993; Zohar, & Dori, 2003). But one can see that the traditional teaching in mathematics as a subject is one of drill and practice within a formula oriented environment, with emphasis placed upon the learner's "correct" or "incorrect" response. The understanding of process within problem-solving should be assessed, and an instrument assessing conceptual understanding, reflective judgment and reasoning is required for preparing 21st-century students. That's why the instrument for measuring achievement in mathematics has been developed.

The test consists of 48 items. The dimension-total correlation coefficient was adequate and good. This indicates that the test instrument was valid. The test-retest correlation coefficient was found to be 0.89 indicates that the test had a good internal consistency. These results indicate that the developed test is valid and reliable; therefore, it can be used to assess students' achievement in mathematics. The result of this research is helpful in future for developing the achievement tests, especially on the particular topics of mathematics. This test can be used by researchers, teachers.

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