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DEVELOPMENT AND STANDARDIZATION OF MATHEMATICAL ACHIEVEMENT TEST (MAT) (GRADE VIII STUDENTS OF KHYBER PAKHTUNKHWA)

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Abstract

The present study aimed to develop a mathematics achievement test for Grade VIII students. The test was designed from the Grade VIII mathematics curriculum and included multiple-choice questions (MCQs) and fill-in-the-blank items. The initial instrument consisted of 80 items and was administered to a sample of 100 Grade IX students. Following item analysis and refinement, 45 items were retained, while 35 items were discarded. The finalized test administration was done on a sample of (N= 100) students to standardize the final version and develop its norms. The test construction and standardization process involved preparing a test blueprint, developing the preliminary draft and answer key, conducting pilot testing, performing item analysis, preparing the final test, establishing reliability and validity, and developing norms. We calculated the discriminative index and difficulty power to evaluate test items. The study assessed test reliability using Cronbach's alpha, which yielded a coefficient of 0.71, indicating acceptable internal consistency. Similarly, the study confirmed validity through subject experts' review and correlation with students' academic records. The study finalized norms by determining the percentile for each raw score. The study has significant implications for educational assessment and other areas of learning, as the standardized test may serve as a useful instrument for evaluating students' achievement in mathematics.

Key Terms: *Achievement, MCQs, Discriminative index, Difficulty Power.*

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INTRODUCTION

Mathematics is the backbone for the economic and technological development of any country. The current developed society cannot exist without mathematics (Ukeje 2005). Hence, it is mandatory to teach mathematics in Pakistan at primary and secondary schools. It is expected to play a major role in the social, economic, and technological development of society. So, the purpose of this study was to create a standardized instrument to measure mathematical achievement. An achievement test is an important tool in the evaluation of a school and is instrumental in measuring the progress of instruction in the different content areas (Mehrens & Lehmann, 1973).

Mathematics

Mathematics is the study of quantity (number theory), structure (algebra), space (geometry) and change (mathematical analysis). Mathematical reasoning can provide explanations or predictions about natural phenomena when mathematical structures are suitable representations of those phenomena. Mathematics has grown beyond the ability to count, calculate, measure, and to systematically study shapes and motions of physical objects; and it has done so through abstraction and logic.

Mathematics fulfils all the criteria for a science and is an effective and necessary tool for all other sciences, including Physics, Chemistry, Engineering and Medicine. The science of all sciences and art of all arts is aptly described by mathematics (Jayanthi, 2014). Mathematics is considered to be the mother of all sciences. The effectiveness of a state is closely related to the development of mathematics, said Napoleon (Ann 2004). Numerical ability tests are used to measure a candidate's problem-solving ability in a correct manner (2011).

Achievement Test

An achievement test measures knowledge, understanding, and skills in a specific subject or group of subjects. It determines how much progress a student has made toward educational goals (Freeman, 2010). These tests assess cognitive abilities and evaluate subject-specific and grade-level knowledge. 'Achievement' refers to learning attainments and proficiencies directly related to a student's educational development. An achievement test systematically determines what a student has learned through instruction (Gronlund, 1976). It provides an accurate representation of students' knowledge and skills in the assessed subject area. Reliable data on student achievement is essential for planning, implementing, and evaluating the curriculum.

Achievement tests identify competent individuals in a specific field. These assessments determine an individual's knowledge or skill level in a particular subject area. Achievement tests are specifically designed to measure skill, accomplishment, or knowledge in defined domains. Distinguishing students' capabilities in specific subjects is essential, as pupils often exhibit significant differences in their attainments. Within school evaluation programs, various achievement tests are used to assess pupils' accomplishments.

Literature Review

Mathematical success is an important determinant of success in the future, especially related to advancing a career. The ability to engage in mathematical thinking is critical to understanding the functioning of society. In response to the continuing reform of mathematics and science education, there has been an increased need for high-quality professional development programs in mathematics and science (Blank et al., 2007). The subject of mathematics is regarded as a critical school subject because of its relationship to improved academic and career opportunities (Akinsola & Tella, 2003). Burton (as cited in Agwagah & Usman, 2003) claims that mathematics plays an important role in scientific, industrial, technological, and social development.

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Besides, Choudhury and Kumar (2009) concluded that positive attitudes of the students towards mathematics are significantly related to their achievement in the subject.

Nannyonjo (2007) found that the variance of mathematics scores was seven percent due to school inputs. The study by Neog (1990) compared the personality traits of the students with their overachievement in English and mathematics. The results indicated that the personality characteristics of overachievers in English were that they were less intelligent, less emotionally stable, less enthusiastic, more socially dependent, and less adventurous than overachievers in mathematics. Copeland (1984) studied various degrees of "knowing" in mathematics, between "knowing how to" and "knowing."

According to Copeland, the solution to a math problem requires mechanical steps to be memorized and depends on memory. Genuine knowledge, however, relies upon understanding the rationale for these steps, which is based upon conceptualization, abstraction, and assimilation. He argues that the focus in education should be on conceptual understanding rather than technical skills. A considerable amount of research has been conducted on mathematical achievement with respect to several variables. Houston (1980), Metcaff (1986), and Prakash and Pandey (1996) reported a significant difference in mathematics achievement for boys and girls.

Harris (1996) stated that students with lower socio-economic backgrounds have more knowledge, understanding, and application of mathematics than pupils with higher socio-economic backgrounds. This is because they have more opportunities than ever to be involved in real-life problems to perform calculations, thus improving their mathematics skills. Further, Hyde et al. (1990) did a meta-analysis on mathematics performance as a function of gender differences and found no gender difference for problem solving at the elementary and middle school levels. However, small gender differences in overall mathematics performance were identified. Anjum (2007) reported a significant difference between the academic achievements of high school overachieving and underachieving girls in mathematics.

Abdulmajeed (1992) identified a positive relationship between intelligence and mathematics achievement. Meese and Parsons (1982), in their study on sex differences in mathematics achievement and academic choice, concluded that competence in mathematics is a critical skill directly linked to educational and occupational opportunities. Compared to men, fewer women choose to enroll in advanced-level mathematics courses or pursue mathematically oriented careers. The above-mentioned studies show the importance of mathematics in different areas of life.

Rationale of the Study

Studies show that poorly designed tests can cause students to lose interest in a subject (Osadebe, 2001; Ohuche & Akeju, 1998). Furthermore, such tests may result in inaccurate assessments and misguided decisions regarding pupils' performance in the subject. Keeping in view this, the current study aims to construct a more valid and reliable measure of mathematical achievement for grade 8 students. The Mathematical achievement test constructed in this study was based on multiple-choice items, as well as some items based on sentence completion (blanks). Thus, it measures students' knowledge and understanding of mathematics in detail. The content area of the current test is spread out to cover the content of the mathematics curriculum.

Statement of the Problem

Development and Standardization of Mathematical Achievement Test (MAT) for Grade VIII students of Khyber Pakhtunkhwa.

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METHOD

Objectives of the study

1. To construct an achievement test that comprehensively assesses the entire Grade VIII mathematics syllabus.
2. To standardize the mathematical achievement test by determining its difficulty level, discrimination index, reliability, validity, and establishing appropriate norms.

Operational Definitions of the Variables

Mathematics

Mathematics is commonly defined as the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions, as well as the study of spatial configurations, their structure, measurement, transformation, and generalization. The Science Dictionary defines mathematics as "the science of measurement, relationship, and properties of quantities and sets using numbers and symbols."

Achievement Test

Downie (1961) defines an achievement test as "any test that measures the attainments or accomplishments of an individual after a period of training or learning."

Sample

The primary objective of this study is to develop and standardize achievement test items in mathematics for grade VIII. The research is based on a survey conducted among grade IX students from private schools in various districts of Khyber Pakhtunkhwa province. The sample for the first try-out was comprised of 100 students enrolled in ninth grade with an equal number of males and females. The age range of the sample was 13 to 16 years. The inclusion criterion was that the students must have passed the mathematics course in eighth grade. The same number of students were used in the final tryout.

Material/ instrument

This study used the Mathematics Achievement Test (MAT) for grade eight. The MAT is structured around three sections of the eighth-grade mathematics curriculum. Test items were developed to assess: 1. Arithmetic, i.e., numbers, fractions, etc. 2. Algebra 3. Geometry, i.e., lines, angles & triangles.

Procedure

The test was developed based on the objectives and syllabus of Grade VIII mathematics. Items were created from the prescribed textbook, ensuring alignment with both objectives and syllabus. Expert input was sought during item generation. Initially, 180 items underwent face validation by three experts in educational measurement and experienced mathematics teachers, with unclear items removed. The validated items were then reviewed by two content experts, who rated their relevance to the objectives and syllabus. After this review, 100 items were discarded. The remaining 80 items were piloted, and item analysis further reduced the set to 45 items.

Conceptual Framework

The current mathematics achievement test was developed through a systematic process that included creating a test blueprint, conducting pilot testing, performing item analysis, establishing reliability, validating the test, and determining norms, difficulty, and discrimination indices. The final standardized test measures eighth-grade students' knowledge, skills, comprehension, and application in mathematics. The development process followed five basic steps:

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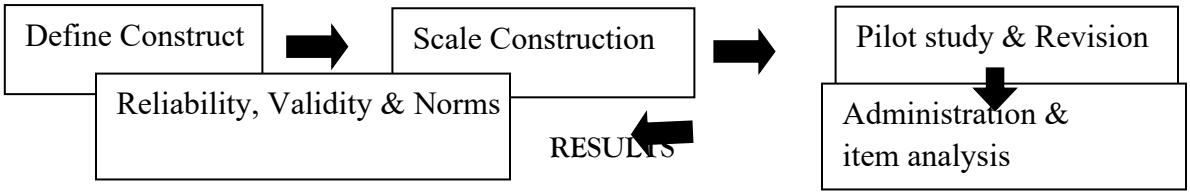


Figure 1: Conceptual Framework

To find out the difficulty level and discriminatory index, SPSS was used. The alpha coefficient of reliability was found, and validity was confirmed through correlation analysis between students' test performance and their performance on the mathematics paper. Percentiles of scores were found to establish the norms.

Table 1: Power of Difficulty Level (P-Level)

Range of P level	No. of Items	Total	Remarks
P≥ 20 & P≤ 80% (Accept)	30,31,34,46,60,73,77,80 25,29,35,44,53,67,56,62, 71,6810,17,19,20,21,26, 27,36,38,39,40,49,58,65, 74,75,7,81,3,4,8,16,37,50, 55,57,5,6,7,11,12,14,15, 18,23,24,28,2,9,13,22,32, 59,61,63, 66,69,70,72,76	78	78 items accepted
P≤ 20 & P≥ 80% (Reject)	45,79	2	2 items rejected
Total Items		80	

Table 1 indicates the difficulty level of Mathematical Achievement Test (MAT) items, and it shows that 78 items are in the acceptable range of difficulty level and hence included in the test, while 2 items, i.e., item no.45 and 79, were beyond the range of acceptable difficulty level and hence rejected from the test.

Table 2: Discrimination index (D-Level) Interpretation Range

Range of D value	Grade	Recommendations
D1>0.39	Excellent	Preserve
D1=0.30-0.39	Good	Possibilities for improvement
D1=0.20-0.29	Average	Need to verify/review
D1=0.00-0.20	Poor	Reject/ Review in dept
D1<-0.01	Worst	Remove

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Table 2 indicates the normal range of discrimination index and following this following analysis of discrimination was carried out.

Table 3: Discrimination index (D-Level)

Range of D level	No. of Items	Total	Remarks
D1>0.39	30,31,34,46,60,73,77,80,25,29,35, 44,53,67,56,62,71,68	18	18 items are at an excellent level
D1=0.30-0.39	10,17,19,20,21,26,27,36,38,39,40 49,58,65,74,75,78	17	17 items lie in Good
D1=0.20-0.29	33,41,42,43,45,47,21,52,54,64	10	10 items lie in the average
D1=0.00-0.20	1,3,4,8,16,37,50,55,57,5,6,7,11, 12,14,15,18,23,24,28	20	20 items lie in Poor
D1<-0.01	2,9,13,22,32,45,59,61,63,66,69, 70,72,76,79	15	15 items lie in the worst level
Total Items		80	

Table 3 indicates the Discrimination index (D-Level) of the Mathematical Achievement Test (MAT) items, and it shows that 18 and 17 items are at the excellent and good levels of the discriminatory index, respectively, and hence included in the test, while 10 items at the average level were modified and then included in the study, while 35 items were at the poor and worst levels and hence rejected from the test.

Table 4: Alpha Reliability Coefficient of Mathematical Achievement Test (MAT) (N=100)

Scale	No. of Items	Alpha Coefficient
MAT	45	.712

Table 4 indicates the alpha reliability coefficients for the Mathematical Achievement Test (MAT). This value is quite satisfactory. This means this scale is internally consistent and reliable for future studies.

Table 5: Correlations between Mathematical Achievement Test (MAT) and Academic Performance (AP)

		MAT	AP
MAT	Pearson Correlation	1	.910**
	Sig. (1-tailed)		.000
	N	100	100
AP	Pearson Correlation	.910**	1
	Sig. (1-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (1-tailed)

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Note: MAT = Mathematical Achievement Test and AP= Academic Performance

Table 5 indicates Correlations between the Mathematical Achievement Test (MAT) and Academic Performance (AP), and it shows there is a significant positive relationship between the Mathematical Achievement Test and Academic Performance of students.

Table 6: Percentiles of Raw Scores

Percentiles	Raw Scores
P_5	17
P_{50}	26
P_{95}	33

Table 5 indicates the Percentiles of raw scores; every fifth point was taken, and the table shows that those having a raw score at or below 17 are ranked at the fifth percentile, i.e. P_5=17 and those having a raw score at or below 26 are ranked at the fifty percentiles $P_{50} = 26$ while those having a raw score at or below 33 are ranked at the ninety-fifth percentile$P_{95} = 33$.

DISCUSSION

The 8th grade mathematics achievement test was developed to assess its difficulty, differentiation, and reliability. Major conclusions were drawn from data analysis using the SPSS program. The difficulty level for each item was found, and items were arranged in ascending order of difficulty; two items that were beyond the range of difficulty level were discarded from the test. Discriminatory analysis showed that a total of thirty-five (35) items had low discriminatory power, and such items were rejected; the remaining forty-five (45) items that were excellent and good based on the discrimination index (D) were retained in the test.

Ebel and Frisbie (1986: 231) state that, although no general provision exists, tests used for individual decision-making should have a minimum reliability coefficient of 0.63. The description indicates that the current test has a positive test reliability value, i.e., 0.71, which is found by the alpha coefficient method. After the refinement of items through this method, the selected items became the basis for the standardization of an achievement test.

The achievement test constructed in the study demonstrates reasonable validity. Content validity, which involves determining the adequacy of each item, was established through careful test planning, appropriate sampling of test items representing the construct, and expert analysis of the items. Statistical validity was assessed by comparing the test items with the objectives of the topics taught. A positive correlation was found between the items and the objectives. Along with these steps, the test results were highly correlated with the students' academic performance in the mathematics course. Therefore, it can be concluded that the test possesses content validity. These findings indicate that the mathematical achievement test used in the study is reasonably valid for evaluation purposes.

Norms serve as a basis for interpreting the scores of individuals or groups within an assessment context. They are empirically established by analyzing the performance of individuals within a representative sample on a given test. The present achievement test established the norms by finding the percentiles of scores, and every fifth point was taken in percentile ranks.

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Conclusion

Finally, achievement tests are valuable tools used to evaluate students' academic progress, for educational selection and certification, for counselling and for the identification of learning difficulties and for informing remedial teaching. They may also be employed for formative assessment and summative evaluation purposes to track student learning progress and identify students' needs. In the present study, a mathematics achievement test was developed and specifically designed to measure the mathematics achievement of the Grade VIII students in light of the prescribed curriculum of Khyber Pakhtunkhwa (KPK). The test is structured in a multiple-choice and fill-in-the-blank format, making it an objective way to measure the mathematical concepts and math learning outcomes that students are expected to know. Moreover, when administered periodically, such assessments could assist teachers in determining areas of difficulty and making decisions about teaching strategies. Overall, the developed and standardized achievement test could be used as a useful instrument in the educational context of Khyber Pakhtunkhwa to assess the mathematics achievement level of the students of Grade VIII.

Limitations

In the current study, certain constraints have to be taken into account, including the limited sample size and the fact that the participants were drawn from certain districts of Khyber Pakhtunkhwa. The research sample, therefore, limits the ability to generalize results to other populations. Because of the preliminary nature of this research, further research is recommended on the psychometric properties of this instrument. Multiple sources of validity evidence, reliability, standardization, and normative comparison procedures are necessary for adequate test interpretation.

Suggestions and Recommendations

- Based on the findings of the study, the following recommendations are proposed: Achievement tests need to be content validated by teachers, researchers or educational authorities to assure that items are related to the prescribed curriculum and learning objectives.
- A set of appropriate cut-off scores and proficiency levels should be set to ascertain what students have mastered in relation to the specified learning objectives and who is needing extra assistance.
- Prior to using achievement tests in educational assessment and decision making, evidence of reliability should be examined to ensure consistency and reliability of results.
- Item Analysis should be used to assess the difficulty, discrimination and effectiveness of distractors. Those that are too easy or too difficult, or of low discriminatory power should be revised or eliminated.
- The number of items in the Grade VIII mathematics achievement test may be augmented to enable students' mathematical achievement to be assessed comprehensively and to cover the entire curriculum.
- The use of item analysis techniques should be part of teacher education and teacher training programs to enable teachers to build their test construction and test evaluation skills.
- Students, teachers and examiners should be provided with seminars, workshops and academic discussions on traditional item analysis techniques to encourage best practice in assessment.
- Educational institutions in KP may use the developed achievement test to evaluate the achievement of students of grade VIII in mathematics, after determining the suitability of the test for the intended population.
- Larger and more diverse samples should be used in future studies to provide further evidence for the test's reliability and validity and its applicability to a wider range of educational contexts.

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- Teachers need to use test results to detect learning difficulties, plan remedial teaching, and to enhance the learning outcomes of mathematics.

Applied Significance

Mathematics is an important science that plays a vital role in science, technology, and other subjects. This study is important because it has made a contribution of a new achievement test in mathematics for Grade VIII level which is standardized and based on the prescribed curriculum of Khyber Pakhtunkhwa (KPK). This tool allows teachers to gauge students' mathematical knowledge, pinpoint areas of need, gauge the achievement of mathematical standards, and design interventions for extra support. The test may also be utilized by educational establishments to measure students' educational progress and make informed choices. Moreover, this study advances the study of educational measurement by giving guidelines for the systematic test construction, item analysis, reliability and validity, and percentile norming.

The reliability of this instrument reaches 0.71 that is in acceptable limits for the internal consistency of this instrument and expert judgment and correlation with students' academic records is considered valid. It may be employed as a valuable instrument for teachers, researchers, and education officials to evaluate mathematics achievement and for designing future assessment instruments. However, other grade levels/student populations will require additional applications to be validated.

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