An Investigation of Students' Learning Difficulties in Mathematics at Secondary Level

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The purpose of the study was to investigate the secondary level students' learning difficulties in mathematics in the areas of Geometry, Arithmetic and Algebra. All math teachers and students of public secondary schools of nine towns of Lahore was the population of this study. The sample of 60 mathematics teachers and 300 students was selected through simple random sampling. Researcher adapted two questionnaires with 21 items each, one for the teachers and other for the students with reliability values 0.966 and 0.941 respectively. Findings of the study revealed that teachers highlight students as feeling difficulty in learning Geometry, Arithmetic and Algebra. Similarly, students also pointed out that they face difficulty in learning Geometry, Arithmetic and Algebra.
Keywords: *algebra, geometry, arithmetic, learning difficulties.*

Introduction

Education is a process of bringing the change in behaviour. The learner needs the knowledge and experience to reshape his/her behaviour. "Learning can be defined as a tentative procedure resulting in a relatively everlasting change in human behaviour that cannot be described by short-term states progress or essential feedback propensities" (Klein, 2002). Mathematics plays a big role in developing human thoughts and systematic intellectual procedures used in problem resolving. It assists people to be able to foresee, plan, choose and suitably resolve each problem in everyday life. Mathematics is also a tool to study technological sciences. Thus, mathematics is useful in our living, helping to improve the quality of life (The Basic Education Core Curriculum, 2008). Moreover, the National Council Teachers of Mathematics (2012) stated that problem-solving expertise is the main expectation of mathematics subject as quoted in (Prathana Phonapichat, 5th World Conference on Educational Sciences - WCES 2013).

However, the term learning means that for all those alterations in the behaviour of the person which the learner goes through during his/her lifetime. "The term learning may be categorized into a number of groups depending upon (a) a field or special area of human behavior in which variations are brought together i.e. verbal learning, motor skills learning, cognitive learning and (b) in the sequence of procedures or systems that are engaged for the overview of the human behavioral changes i.e. experiment and learning, classical conditioning, operant conditioning, chain learning, shaping, learning through simplification. Learning through discernment, ongoing learning, secondary learning, intuitive learning, and so on" (Mangal, 2003).

Learning is an integral part of education, it brings change in behaviour. The learner needs the knowledge and experience to reshape his/her behaviour. It

can be intentional or unintentional. It is not limited to school but it takes place everywhere. "Learning as a whole is not confined to the formal classroom learning activities, life presents enormous opportunities to learn and learning activities are so numerous that it is difficult to limit them in any specific categories" (Kumar, 2005. P, 283). "The term learning can be described as tentative process causing a comparatively everlasting change in the human behaviour that cannot be clarified by momentary states growth or native feedback trends" (Klein, 2002. P, 110). "Learning is a process that causes a permanent change in knowledge and behaviour" (Woolfolk, 1998. P, 271).

"Children with a range of problems-primarily social and emotional worries, primarily intellectual problems, primarily motor (movement) problems or a combination of all three find they are not able to manage with the busyness of the new environment" (Macintyre, 2005. P, 142). Learning difficulties are the term which refers the student's difficulties they face in learning. Difficulties in gaining understanding and expertise to the ordinary level are mainly because of the mental ill health or mental disorder of such people. "Learning disability" is the term used to a variety of problems starts when material from the brains is not correctly acknowledged by their brain. Researchers aimed to investigate the learning difficulties of public secondary school students in Mathematics at the secondary level.

Objectives of the Study

The research objectives were :
1. To examine students learning difficulties in Geometry.
2. To examine the students learning difficulties in Arithmetic.
3. To examine the students learning difficulties in Algebra.

Research Questions
1. Do the students feel difficulties in comprehending the concepts of Geometry?
2. Do the students feel difficulties in comprehending the concepts of Arithmetic?
3. Do the students feel difficulties in comprehending the concepts of Algebra?

Literature Review

Typical feeling to see mathematics as practical, valuable and fixed with confidence in persistence and one's own efficiency (Donovan, 2005). Mathematical expertise is developed by adopting the following principles.

1) Consideration: Understanding mathematical theories, procedures and relations-knowing what math signs and figures. 2) Calculating: Functioning math techniques like adding, subtracting, dividing and multiplying numbers correctly. 3) Relating: Being competent to articulate mathematical problems in order to propose approaches for resolving them with impressions and techniques properly. 4) Cognitive: Using logic to clarify and rationalize the resolution to issue or to prolong from somewhat known to somewhat unknown. 5) Engaging: "Foreseeing math as useful and sensible doable-if you work at it-and willing to do the work" (Kilpatrick, 2002. P, 18).

If knowledge is a modification in human behaviour, then for measuring it one must measure variations in human behaviour. It can be completed in various ways. "A mutual method of computing the knowledge is check decrease in faults. A Rat can be described to learn how to run a maze to a level which goes from beginning till the end without taking the incorrect move" (Chance, 2003. P, 92).
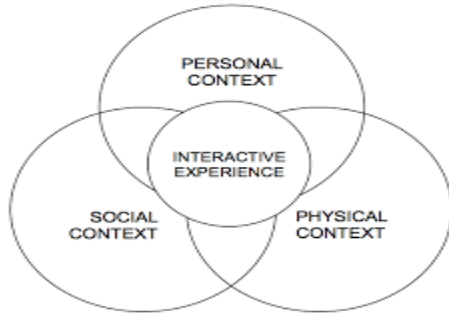
Fig. 2.1: A Contextual model of learning
in informal (Braund, 2000).

Learning Difficulties in Mathematics

Mathematics and Mathematics Structure Mathematics deals with structures and relationship between structures, rather than so-called 'mathematical objects'. In other words, mathematicians have become aware that the 'objects' of their science are particular mental constructs to which they apply their mental dynamism in order to make explicit the content involved in them by virtue of the embedded structures (Gattegno, 1963). View of eminent Mathematics Education & the evidence revealed by different researchers, relevant to this study will be discussed in brief. Mathematics: a conceptual study and Mathematics: a relational study, whereas, modern methodologies to enlighten mathematics refer to the learning features of math underachievers: mental expressive approach: mental problems occur with math difficulties. Error analysis approach emphases on the types of the errors made by scholars. Neuropsychological approach links math difficulties to neurological disorders-dyscalculia. Information-processing approach associates vocal, memory and perceptual processing with math problems.

Mentioned approaches emphasis on learners in exclusion instead of on students in terms of students-teachers' collaborations in their previous and current learning scenarios" (Munro, 2016). Usually, mathematical problems are composed of controlled and basic activity but later these

are identified with the help of other methods and techniques like changing the state's data, analogy and etc.

Formalize investigational statements, with as much numerical verification as possible; In geometry, make the auxiliary structures that are erased after construction of problem statements; Initiating with problem (theorem), produce another problem (theorem) using mathematical logic; Beginning from a problem (theorem), make a new problem (theorem) using generalizations and analogies etc. Founding of acquaintances within unlike domains (mixtures); Resolving of a known problem, using additional technique" (Bairac, 2008). "Spatial knowledge consists of two aspects: one is shaped like the number of sides and angles and second is position or location in space. The types of spatial problems displayed by the underachievers are problems dealing with directional concepts such as up and down, right and left. Problems with the elementary spatial ideas such as 'inside', 'above' and 'under'. A spatial idea is related to unsuitable criteria. The child cannot 'act mentally' in a shape or imagine it being altered or converted. The idea of angle and the degree of rotation cause trouble. The child uses unsuitable perceptual features to categories the shapes. Child has the trouble demonstrating 3-dimensional substances in 2-dimensions" (Mulligan, 2011)

The findings of a study about Mathematics Learning Difficulties in Early Primary School Years are following. The acute analysis of the construct, its inferences for children and the tools for recognizing the precise learning difficulty; empirical reports of children's theoretical knowledge of the basic principles that motivate single-digit addition; proof pertinent to theoretical models of the association between procedural and conceptual knowledge in the subject of mathematics (Ismail, 2007).

Learning Difficulties in Signs and Symbols

Signs and symbols are mostly used in Geometry, Arithmetic and Algebra. These symbols often confuse the learners during learning. Some important symbols are given below.

+ Plus: sign addition 5 + 4

− Minus: signs of subtraction 6 − 2

∗ Multiplication: sign of multiplication 5 ∗ 3

÷ Division: 6 ÷ 2

= Equals: 2 + 3 = 9 − 4

≠ Not equal to: 2 + 3 ≠ 9 − 6

> Greater than 9 > 4 or 9 is greater than 4

< Less than: 3 < 8 or 3 is less than 8

∞ Infinity: Greater than any number we can write, speak or think

° Degree: Unit of measurement of an angle; a complete circle has 360°

Π Pi: Used to calculate the circumference and area f a circle; it equals 3.14159

⊥ Perpendicular to Forms a right angle, ‖ Parallel to Continues in a straight line and never meets.

Learning Difficulties in Geometry

Geometry means the pure mathematics of points, lines, curves and surfaces. It is categorized as either Straight Line Geometrics such as the rectangles, triangles, trapezoid, octagons, pentagons etc., or Radius Geometrics which comprise half-rounds, quarter-rounds, full-rounds, sectors, ellipses etc. it is as clear as crystal that geometry is the base and essential part of mathematics. The learners usually feel difficulties in drawing the different objects and also calculating their sides and other aspects.

Learning Difficulties in Arithmetic

Mathematics of the numbers under the processes of addition, multiplication, subtraction, division, rising to authorities an idea of origins is also known as arithmetic. Some students feel difficulties in discriminating the rational and irrational numbers. And mostly the students face the difficulties in the operation of divisions especially by using the tables (Terezinha, 2014).

Learning Difficulties in Algebra

Algebra is the language used to direct mathematical relationships. Students need to comprehend how quantities are connected to one another and how Algebra can be used to exact express and examine those relationships. Some students feel difficulties because of under comprehension and conversion of word statements into mathematical form. "Students experienced difficulties such as (1) deficiency of understanding of the problem posed, (2) deficiency of policy knowledge, and (3) incapability to interpret the problem into a mathematical form" (Yeo, 2009).

Many studies have exposed that students' considerate of symbols in the algebra is not appropriate because some of the problems faced by the students are specific to algebraic terms (Kuchemann, 1981). The misunderstandings about the equal sign are mutual in the students of Algebra. The idea of equality is an important idea for developing algebraic ideas among the students of the Algebra. NCTM (2009) showed the significance of the idea of the equal sign (=) and recommended that more importance should be positioned on students' understanding of equal sign to ensure a basis for learning Algebra.

The students' observations about the symbols, letters and signs and the effect of their observations on their learning of the Algebra in the conclusions of the study are. "The study exposed that the students have many misunderstandings in the use of symbols in Algebra, which affect their knowledge of Algebra. It is vigorous that students know that the symbols that are used to signify an unknown measure or variable have changed context" (Ali, 2009).

Specific Learning Difficulties in Mathematics

Structural Complexity

Structural complexity is the discipline of applied mathematics, that aims at connecting fundamental physical or biological aspects of the multifaceted system with the mathematical explanation of the morphological complexity that the system shows, by establishing demanding relations between mathematical and physical belongings of such system. This unit deals with the structural complexity of the Mathematical objects. The present study includes one question involving Mathematical complexity to test its effect on the performance of the students. It seems very easy for the students to select the quantities, which are included in the verbal problems, however, it is very difficult for them to form an algebraic or an arithmetic expression that involves operations (Ricca, 2016).

Structure of Mathematics

The structure of Mathematics is found in three basic structures:

- The Algebraic structure based on the concept of operation.
- The ordering structure based on the relations.
- The topological structures based on such concepts as continuity and proximity.

Love (1970) report one such study by Orton in which, the function was presented in a wider range of situation relation being. Presented by t diagram, by the graph, by ordered pairs, and by equation clear stags in the growth of understanding of the concepts were observed. The concept of point and limit are an important one. Piaget, Helder and Szeminska who showed that it is not until the age of maturity to define the terms formally, first studied the growth of the former. A science of relationships and operations, the most important thing in teaching and learning Mathematics is not to understand the quantities but it is to recognize the Mathematics relationship between the quantities. The complex categorization and establishment of a relationship between the categories are known as the science of Mathematics relations are then established between numbers and even these relations between are categorized. These categories are further related to each other in order to relate each other we need things to relate. We need in terms of relations between the elements given in the problems, thus the solution of the Mathematical problem is the solution of the relations given in that problem and not the symbolization of string of individual words (verbal formation). There are many instances, in which the keywords in the statement of the problem can serve as cue words, which led directly to the mathematical operation, required for the solution.

Problem of Learning Structure

Having discussed what is meant by Math, we are now in a position to discuss what is meant by learning Math. Knowing what we are learning is a necessary condition for knowing what it is to be learning it. It is not, however, sufficient. Learning itself is a psychological set in which the input is the student, who do not know a particular piece of Math in order to ascertain whether our teaching is effective or not, we would need to have a criterion for judging in every case whether the piece of Mathematics has or not been learnt. No, if mathematics consists of relationship between certain categories, relationships between this relationship soon, then we would need to device some kind of test or verifying whether a student does know such structure or not, this criterion is of practical nature that is construction of test problem, testing and interviewing students and analyzing the students' responses.

Mollory (1976) found the following major computational difficulties while studying the problem of adapting Mathematics instruction of Secondary Students. Renner (1973) found some instructional difficulties and stated. Cost of instruction is significantly reduced and the instruction effectiveness increased without affecting student achievements by having large classes with student's assistant doing at least part of the routine work. The Instructional problem of Secondary Math has been concerned with the following.

Methodology

The study falls in postpositivism paradigm and accordingly, the quantitative approach has been adopted to conduct the research. More specifically, the study is descriptive in nature. The researchers adapted two questionnaires, one for the students and other for the teachers. The panel of experts validated the questionnaires. Data was collected personally by the researchers. Researchers accessed the research sites through taking permission from the relevant authorities such as Executive District Officer (EDO) and principals. Before data collection, informed consent was taken from the respondents. It was assured to the principals, teachers, students and EDO that data will only be used for the research purpose for which it is being requested. Moreover, it was assured that data will be kept confidential and anonymous. Factors (Geometry, Arithmetic and Algebra) within

Table 1

questionnaire were tested individually for reliability and reliability of the entire questionnaire was also tested. The data have been analyzed by means of inferential statistics i.e. Chi-Square Test. Chi-Square is used when the sampling method is simple random sampling and the variable of the study is categorical and each variable is independent.

All math teachers and all secondary level students of the public secondary schools of nine (9) towns of Lahore constituted the population of this study. The sample was selected randomly from three towns (Allama Iqbal Town, Samanabad Town and Ravi Town) as follows: (a) 60 mathematics teachers (30 male, 30 female) were randomly selected; (b) 300 students (150 male, 150 female) were randomly selected - 100 students (50 male, 50 female) from each town were selected as sample.

Instrumentation

The researcher adapted two questionnaires for the investigation of students' learning difficulties in mathematics, one of the students of secondary level and other for the teachers of Mathematics. There were twenty-one items in each questionnaire and the questionnaires response format was 4-point Likert scale. Each questionnaire was divided into three sections geometry, arithmetic and algebra. Detail of these sections with their indicators is presented below in Table 1.

Types of Difficulties and their Indicators

Types of difficulties	Indicators
Geometry	Written statements
	Drawing geometrical diagrams
Arithmetic	Table learning
	Adding and multiplying long terms
Algebra	Application of different formulas
	Algebraic operations

Questionnaire for Students developed and used by Ahsan Ullah (2007) was a much

suitable instrument for the study at hand. The researchers adapted this questionnaire

for the identification of learning difficulties in mathematics subject for the students of secondary level. The validity of the instrument was ensured through a panel of experts of the corresponding field. To find out reliability in this study's context Cronbach's Alpha was calculated for each of the factors, by using SPSS. The factors with their reliability are given in Table 1.

Table 2

Reliability Values for Factors of Questionnaire for Students

Factors	Item Numbers	Cronbach's Alpha Reliability
Geometry	1,2,3,4,5,6,7,8	.862
Arithmetic	9,10,11,12,13,14	.703
Algebra	15,16,17,18,19,20,21	.713

Questionnaire for Teachers was also adopted by the researchers for the identification of learning difficulties in Mathematics. This questionnaire was developed by Ahsan Ullah in 2007. To find out the reliability of in this study's context, Cronbach's Alpha was calculated for each of the factors, by using SPSS. The factors with their reliability are given in Table 2.

Table 3

Reliability Values for Factors of Questionnaire for Teachers

Factors	Item Numbers	Cronbach's Alpha Reliability
Geometry	1,2,3,4,5,6,7,8	.915
Arithmetic	9,10,11,12,13,14	.894
Algebra	15,16,17,18,19,20,21	.586

Pilot Study

A pilot study was conducted in a Government High School Lahore. The adapted questionnaires were administered personally by the researchers. Fifty students from 9th and 10th class were taken as a sample. And fifty teachers who teach mathematics were taken as respondents from different public schools of Lahore city. These respondents were other than the sample of the actual study. All the teachers were teaching Mathematics to 9th and 10th class. With the discussion of teachers who teach Mathematics, the deficiencies in the questionnaire were removed. Data were analyzed by mean and variance separately for both the questionnaires.

Reliability of Questionnaire for Students; a detailed factor wise description is given below in Table 4 and cumulative Cronbach's Alpha value of the questionnaire is presented in Table 5.

Table 4

Factor wise Cronbach's Alpha value of the questionnaire for students

Questionnaire for Students Factors	Number of Items	Serial Number in Final Scale	Cronbach's Alpha Reliability
Geometry	8	1,2,3,4,5,6,7,8	.955
Arithmetic	6	9,10,11,12,13,14	.918
Algebra	7	15,16,17,18,19,20,21	.764

Table 5

Cumulative Cronbach's Alpha value of the questionnaire for students

No. of Items	Mean	Cronbach's Alpha Reliability
21	2.004	.941

Reliability of Questionnaire for Teachers; a detailed factor wise description is given below in Table 6 and cumulative Cronbach's Alpha value of the questionnaire is presented in Table 7.

Table 6

Factor wise Cronbach's Alpha value of the questionnaire for Teachers

Questionnaire for Students Factors	Number of Items	Serial Number in Final Scale	Cronbach's Alpha Reliability
Geometry	8	1,2,3,4,5,6,7,8	.914
Arithmetic	6	9,10,11,12,13,14	.903
Algebra	7	15,16,17,18,19,20,21	.874

Table 7

Cumulative Cronbach's Alpha value of the questionnaire for Teachers

No. of Items	Mean	Cronbach's Alpha Reliability
21	2.170	.966

Data Analysis and Interpretation

Usually, Non-Parametric tests are used for nominal and ordinal scale but parametric tests are used for interval scale and ratio scale. "Thus, Chi-square is suitable when data represent a nominal scale, and categorize may be true categories". Meaning that Chi-square is used when data signifies nominal scale and each observation is independent – as is the case of this study. There are two types of Chi-square such as one sample test and two sample tests. The analysis of the responses of the teachers about the learning difficulties in subject of the Mathematics, and analysis of the student's responses about their learning difficulties in subject of the Mathematics are below; where N stands for Total No. of teachers/students, SD = Standard Deviation, df = Degree of Freedom, p = Significance value, O = Observed value, E = Expected value, χ^2 = Chi-square value.

Chi-Square Distribution regarding Teachers' Responses about Geometry

Total $\chi^2 = 99.8$, (df) = 18 ,p = 0.044 and $\alpha = 0.05$

Conclusion: χ^2 (18, N=160) = 99.8, p = 0.044 < 0.05

P value = 0.044 and is less than α value = 0.05, so it is concluded that teachers observed that the students feel difficulty in comprehending Geometry.

Chi-Square Distribution about Teachers' Responses about Arithmetic

Total χ^2 = 76.3, (df) = 11, p = 0.007, α = 0.05

Conclusion:χ^2 (11, N=120) = 76.3, p = 0.007 < 0.05

Here *P* = 0.007 and is less than α = 0.05, therefore it is concluded that teachers observed that the students feel difficulty in comprehending Arithmetic.

Chi-Square Distribution about Teachers' Responses about Algebra

Total χ^2 = 78.5, (df) = 14, p = 0.043, α = 0.05

Conclusion:χ^2 (14, N=140) = 78.5, p = 0.043 < 0.05

Value of *P* = 0.043 and is less than α = 0.05, thus it is concluded that teachers observed that the students feel difficulty in comprehending Algebra. *Chi-Square Distribution about Students' Responses in Geometry*

Total χ^2 = 649.52, (df) = 24, p = 0, α = 0.05

Conclusion:χ^2 (24, N=800) = 649.52, p = 0 < 0.05

Here value of *P* = 0 and is less than α = 0.05, so it is concluded that the students feel difficulty in learning Geometry.

Chi-Square Distribution about Students' Responses in Arithmetic

Total χ^2 = 418.7, (df) = 18, p = 0, α = 0.05

Conclusion:χ^2 (18, N=600) = 418.7, p = 0 < 0.05

P value = 0 and is less than α = 0.05, therefore it is concluded that the students feel difficulty in learning Arithmetic.

Chi-Square Distribution about Students' Responses in Algebra

Total χ^2 = 519.6, (df) = 21, p = 0, α = 0.05

Conclusion:χ^2 (21, N=700) = 519.6, p = 0 < 0.05 The value of *P* = 0 which is less than α

= 0.05, so it is concluded that the students feel difficulty in learning Algebra.

Conclusions

The following conclusions are drawn from the findings. In general, both the respondents (teachers and students) support each other that the students feel difficulty in learning Geometry concepts. Similarly, both the respondents (teachers and students) agreed that student feels difficulty in comprehending Arithmetic. Moreover, both the respondents (teachers and students) augment each other opinion that student feels difficulty in learning the concepts of Algebra.

Discussion

Similarity is observed between the present study and earlier studies such as "*Teaching algebra to students with learning difficulties: An investigation of an explicit instruction model*" by Witzel (2003) and "*Mathematics growth in early elementary school: The roles of beginning knowledge, student engagement, and instruction.*" by Bodovski (2007) that most of the students did feel difficulties in understanding the Mathematics especially in Arithmetic. But there was the difference between the Ahmed study and Ahsan Ullah study with reference to learning difficulty in algebra and geometry. Witzel (2003) mentioned that student feels difficulties in algebraic expressions and geometry whereas Bodovski (2007) study revealed that students feel less difficulty in geometry as well as in algebra. Whereas, present study findings support Witzel (2003) results in more as compared to Bodovski (2007) study results.

Recommendations

The following recommendations and suggestions for future research are made on the basis of the current study:

1. Practitioners, head teachers, curriculum developers and books/learning material developers might use the results of this study to improve the teaching/learning

of mathematics. If this study is replicated on other similar population groups and on other levels such as primary and higher secondary levels, it may contribute to the theory as well.

2. This study was conducted on the specific aspects of students' learning difficulties in Geometry, Arithmetic and Algebra. So there may be research studies on the other aspects like set, proportion and average of Mathematics.

3. This study was conducted on the more general aspects of normal students' learning difficulties like Input, Integration, Storage and Output; specific learning difficulties of students with Alexia, dyslexia, dyscalculia, dysgraphia and aphasia may be considered in future studies.

4. This study was conducted on the learning difficulties in the subject of Mathematics. So, there may be research on the other subjects like science, social studies and languages as well at the secondary level and others levels.

5. This study is conducted in Public sector, so there is a need for further research studies in Private sector.

6. For the generalization of the results of this study, such studies may be conducted in other towns of Lahore or in other parts of the country.

7. This study used structured questionnaires. There is need to use other tools and to involve the qualitative approach to make the results more credible.

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