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A Critical Analysis of Problem Posing in the Mathematics Curriculum at Secondary Level

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Abstract: ***Mathematics curriculum has undergone various changes from time to time to fulfill the goals of Mathematical Education and to its social relevance. Mathematics is considered as a compulsory subject of general education. But when separate periods are allotted for learning and teaching mathematics, these Basics of Mathematics tend to be isolated from the real context and taught formally. The present study is an attempt to find out the number of problem references in the developmental and testing stages of mathematical concepts at secondary level. The Mathematics Textbook (SCERT, Kerala, Standard X) was analyzed in terms of real-context based and formal problem references used for developmental and testing stage. The study revealed wide range of contexts embedded with mathematical components.***

Keywords: Problem Posing, Mathematics, Curriculum, Secondary Level

1. Introduction

Mathematics is probably the oldest organized discipline of human knowledge, with a continuous line of development spanning over 5,000 years. It is a body of ideas structured by logical reasoning. The facts, principles and methods developed in early Mesopotamia, Egypt and Greece play central roles in the learning of the subject even today. The sustaining social interest in mathematics is based on at least four major themes in its development; (1) the arithmetic of whole numbers and fractions for recording and ordering commerce and practical affairs; (2) The ideas of Algebra, Geometry, Statistics and Calculus providing valuable models in the biological and physical world; (3) the aesthetic qualities of mathematical structures embodied in art; (4) the patterns of logical reasoning in mathematical proofs carried over in many other disciplines.

Mathematics curriculum has undergone various changes from time to time to fulfill the goals of Mathematical Education and to its social relevance. Mathematics is considered as a compulsory subject of general education. But when separate periods are allotted for learning and teaching mathematics, these Basics of Mathematics tend to be isolated from the real context and taught formally. At its best, it may be the abstraction of the highest order. But only the minority of students reaches this level. As far as the majority in this system is concerned, the process involves sheer rote memorization, repeated drill, examination orientation, threat of punishment etc. Observation of hundreds of classroom situations in the ordinary school show that, on the whole, the focus on skills and mechanical repetition seems to predominate. In many schools, even the skills are not actually developed by the pupils or drawn out of mathematical problem reading, analyzing, creative hypotheses formulation and testing them by using the relevant data. An artificial problem - very much unlike the problem that one faces in real life – is presented before the pupil, which might include mathematical components too. The teacher 'explains' the problem and 'how to do it' and get the answer. Most pupils do not really seize the problem. The teacher artificially 'motivates' the pupils to 'do the sum', and tries to show 'how to do it'. When the pupil does not grasp it, teacher himself does it for the pupil and the pupils copy the steps in their notebook. Occasionally we do find innovating and resourceful teachers who can introduce mathematical problems close to our conditions.

Problems can be especially appealing when they spring from the environment in which students live. But in the ordinary classrooms this phenomenon is getting less and less. Most pupils wait for the teacher or his 'deputy' to work out the problem on the blackboard and then copy the steps and the answers in their notebooks. When this happens, School Mathematics gets isolated not only from its practical context, but also from the true world of joyful mathematics. This would turn the young minds wrestling with mathematical problems to a veritable hell of drudgery, routine and mechanization. Buishaw and Ayalew (2013) attempted a document analysis to evaluate the adequacy of integration of problematic situations and general problem-solving strategies (heuristics) in grades 9 and 10 mathematics textbooks.

Objective

To find out the number of problem references in the developmental and testing stages of mathematical concepts at secondary level.

Method Adopted

The Mathematics Textbook (SCERT, Kerala, Standard -X) was analyzed in terms of real-context based and formal problem references used for developmental and testing stage.

2. Results and Discussion

Analysis of mathematics textbook -Standard X -- Part I

Based on the analysis of chapter "**Arithmetic Progression**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 1

Table 1: Number of problem references at developmental stage of mathematics concepts and principles as well as at the testing stage in the chapter Arithmetic Progression

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	10	_	10
Testing stage	37	3	40

For the concept development, 10 formal problems are used. Illustrations using tabular devices are also used effectively. 40 practice problems are given at the testing stage of which only 3 are real world context-based problems. The approach is through empirical measurement and inferences are followed by an enormous amount of formal written exercises.

Based on the analysis of chapter "**Circles**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 2

Table 2: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Circles

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**11**	**_**	**11**
Testing stage	**25**	**_**	**25**

For the development of each concept, formal examples with appropriate diagrams are presented. In the exercises, there are no typical real life context-based problems. 11 formal types of problems are used at the developmental stage and 25 such problems are used at the testing stage.

Based on the analysis of chapter "**Real Numbers**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 3

Table 3: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Real Numbers

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**22**	**-------**	**22**
Testing stage	**15**	**--------**	**15**

The concepts, methods of solutions and other sub units are developed formally. 37 formal problems are presented, of which 22 are at the developmental stage and 15 are at the testing stage. Any typical type of context-based problems is not given.

Based on the analysis of chapter "**Quadratic Equations**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 4

Table 4: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Quadratic Equations

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**21**	**_**	**21**
Testing stage	**32**	**2**	**34**

Revision of simple equation is followed by formal treatment of simultaneous equations. The steps in the formal proof are stated clearly. Only two application problems from real life are suggested at the testing stage. Very systematic illustrations and drills are given for the new skills. For concept development, 21 formal examples are used for all the sub sections. At the developmental stage, it doesn't include any real context-based problems.

Based on the analysis of chapter "**Tangents**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 5

Table 5: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Tangents

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**6**	_	**6**
Testing stage	**22**	_	**22**

Geometrical proofs are presented at the developmental stage. Theoretical geometry of circles is also discussed. There can be no complaint that this is formally treated, because formal proofs are expected to be studied at this stage. However, for the student who has not reached formal operational stage for dealing with these for want of concrete operational base, the teacher might think of the needed bridges. 22 practical problems with diagrams are given, but they are of a formal nature. (But students were found to have difficulties)

Analysis of mathematics textbook -Standard X -- Part II

Based on the analysis of chapter "**Polynomials**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 6

Table 6: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Polynomials

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**25**	_	**25**
Testing stage	**42**	_	**42**

This unit is entirely symbolical and formal. There are 25 formal problems presented for the development of the theorems – Remainder Theorem and Factor Theorem. All exercises suggested at developmental and testing stages are formal. The environmental oriented and picture –oriented examples are not suggested in this chapter.

Based on the analysis of chapter "**Solids**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table7

Table 7: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Solids

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	16	6	22
Testing stage	24	11	35

All the mathematics concepts and principles are derived through induction and from observational study of models. Pictures of different concepts are given as diagrams. The terminal behavior of course is that children should get the results from imagined pyramids or even from symbols.

Cross section of a square pyramid, its height, slant height and the relationship between height, slant height and base are all explained through pictures and explanations. Here too experiments showed that most students had difficulty with three dimensional figure, especially about differentiating between the slant height and the 'hidden' height of the pyramid itself.

Surface area and volume of a cone are developed through pictures, explanations and invitation to improvise cylindrical vessel and a conical vessel having the same height and same radius and to measure out sand and discover that volume of conical vessel is one-third of the volume of cylinder. For the development of the 'frustum of a cone', popular environmental words are used which can help to relate with e everyday situations and understand the concept. There is only one real context-based problem.

17 application (real context) problems are given, of which six are used at the developmental stages of the mathematical concepts. Useful pictorial illustrations are also given. All the concepts are developed through verbal real world problems numbering 6 at the developmental stage and 11 at the testing stage in addition to the 40 formal problems.

Based on the analysis of chapter "**Trigonometry",** the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified are given as Table 8

Table 8: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Trigonometry

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	**3**	**4**	**7**
Testing stage	**21**	**7**	**28**

The unit is started formally after the review of the related topics. The second half of the chapter, dealing with angle of elevation, depression etc. contains a high practical element with 4 practical problems and 7 highly practical activities. Seven illustrated at the developmental stage, of which 4 are real context based. 28 problems are given as practice problems at the testing stage, of which 7 are real context based, Trigonometric table is given at the end of the chapter.

To familiarize the eminent mathematicians (Euler, Gauss, Lobachevski, Henric Abel), the pictures are given at the end.

Based on the analysis of chapter "**Analytic Geometry",** the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified are given as Table 9

Table 9: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Analytic Geometry

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	5	_	5
Testing stage	18	-	18

All the exercises are formal. The approach is through empirical measurement and the inferences are followed by enormous amount of formal written exercises. For the concept development 5 formal examples are used at the developmental stage and 18 at the testing stage. No real context oriented problems are seen. Pictorial examples are given as exercises.

Based on the analysis of chapter **"Statistics**", the number of problem references as formal and real-context under the developmental stage as well as the testing stage identified is given as Table 10

Table 10: Number of formal problems and real context based problems in the developmental stage and testing stage for the chapter Statistics

Stage	Formal problems	Real context-based problems	Total problem references
Developmental stage	_	5	5
Testing stage	_	10	10

Students are invited to everyday life problems involving the concepts Mean, Median, Mode with the help of environmental problems as examples (5 at the developmental stage and 10 at the testing stage). Pictures of eminent mathematicians namely Riemann, Cantor, Hilbert and Srinivasa Ramanujan are given at the end of the chapter.

After the analysis of the mathematics textbook, the investigator identified the different units under different branches of mathematics. Six branches are presented at secondary level. Some new branches like Analytical Geometry is presented at standard. The secondary school mathematics textbooks provide numerous real contexts of problem references either in developmental stage or at the testing stage. The contexts have the exact picture of the society, so that students can familiar with the real world problems that may confront in their real life.

3. Discussion

From the detailed analysis of the mathematics textbooks (X^{th}), the investigator found a wide range of problem references as formal and real-context based at the developmental stage as well as in the testing stage. There are sufficient number of worked out examples for the meaningful formation and attainment of mathematical concepts and principles.

Pictorial and diagrammatic representations are given wherever necessary. Though the illustrations are simple, it invites the students to complete the process in solving certain problems. There are numerous situations for problem posing and problem representations at the developmental stage. Gradation of the concepts is well enough for the meaningful understanding of mathematical components. It is better to give a diagram showing the inter connectedness among the mathematical concepts. Concept mapping would strengthen and culminate the mathematical connections, which lead the learners to develop mathematical communications.

The inter connectedness of the mathematical branches like Arithmetic, Algebra, Geometry, Trigonometry, Analytical Geometry etc to be emphasized in its appropriate forms.

This would help the learners to perceive the meaning of mental representations as a gate way to solve the problems in mathematics. Concept Mapping would help the learners build their own pre -requisites and can transfer in similar situations they are confronted. Conceptual understanding is important for the students for in-depth analysis of mathematical concepts. When students understand mathematics, they are able to use their knowledge 'flexibly' they combine factual knowledge, procedural facility and conceptual understanding in powerful ways,

Learning the 'basics' is important; however, students who memorize facts or procedures without understanding often are not sure when or how to use what they know. In contrast, conceptual understanding enables students to deal with novel problems and settings. Finding ways to help students ask answer mathematical questions can be the basis of sound mathematical and creative thinking and in-depth understanding of mathematics.

4. Conclusion

From the in-depth analysis of the textbooks, the investigator tried to highlight the findings of Shoenfeld (1992), who described a 'spectrum' of understanding regarding mathematics. At one end, math is seen as a body of facts, procedures and formulas. If one has learned the procedures, one knows the math. At the other end, math is seen as the science of patterns, closely akin to the sciences. Shoenfeld believed "a curriculum based on mastering a corpus of mathematical facts and procedures is severely impoverished-in much the same way that the English curriculum would be considered impoverished if it focused largely, if not exclusively, on issues of grammar" this perspective was echoed by the National Research Council (Kilpatrick, Swafford & Findell, 2001).

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