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Review, Findings and Recommendations for Development of Elementary Mathematics Curriculum

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Abstract

The philosophy, specific objectives of teaching mathematics, and expected learning outcomes stipulated in the National Curriculum 2000 for Mathematics Classes VI - VIII served as part of the basis of the framework for reviewing the mathematics curriculum for Middle classes. Current international thrusts in mathematics education such as the focus on problem solving, emphasis on the development of thinking skills and positive dispositions, use of technology whenever it is appropriate and available, and research on how students learn mathematics are taken into account in this study. The framework given in the paper shows at a glance what the curriculum should consider as valuable for the students to learn, what they should learn and how they should learn them. This paper gives guidelines, synthesises findings and recommends some key elements for further development and improvement of elementary mathematics curriculum in Pakistan.

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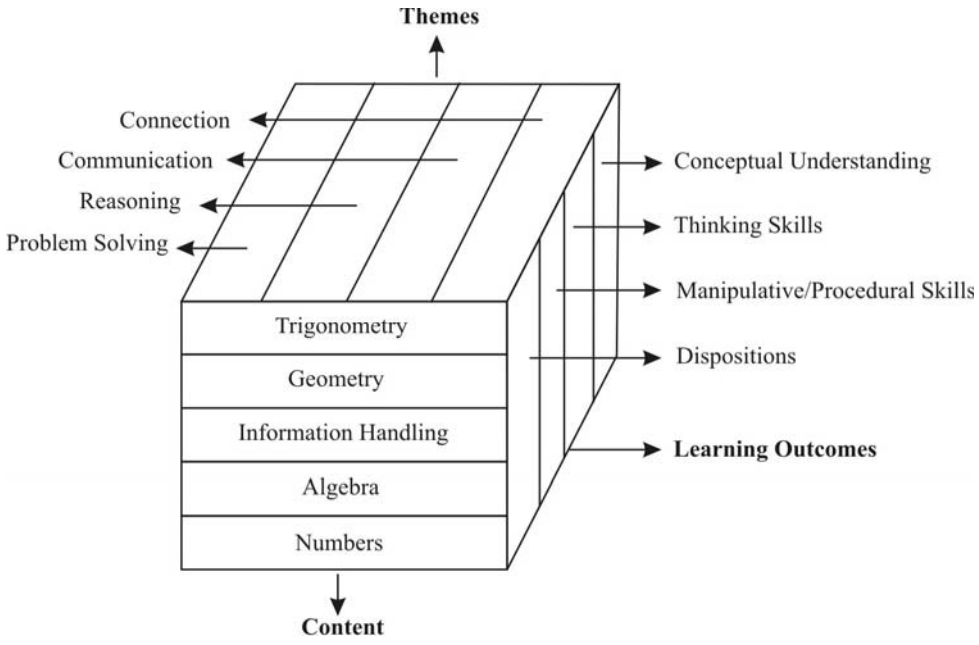
The Mathematics Curriculum Framework

The framework that is used to review the mathematics curriculum for the different classes considers the content, themes, and learning outcomes. The guiding principle is that students learn mathematics best when they are intimately engaged in doing mathematics. This implies that in all the content areas, the themes that should cut across are problem solving, reasoning, communication, and connection. All these themes require the active involvement of students in generating mathematical ideas and transferring them to new contexts. The content of mathematic curriculum 2000 covers Numbers, Algebra, Information Handling, Geometry and Trigonometry (for class X) and in greater depth and complexity as the class level increases. The learning outcomes put equal importance to conceptual understanding, development of thinking skills and manipulative/procedural skills, and acquisition of positive dispositions. The three dimensional model below depicts the framework. The dimensions interact in ways that, as students learn any content, they experience all the themes, which should result in the attainment of the learning outcomes.

Framework for Reviewing the Mathematics Curriculum



Content

- NumbeReasoning
- Algebra
- Information Handling
- Geometry
- Trigonometry (in claConceptual Understanding

Themes

The themes are described in detail in as much as these are usually not consciously and consistently given the needed attention that they deserve in the curriculum.

- Problem Solving
  The main method as well as the goal of mathematics teaching should be to develop students' ability to solve problems. The students acquire this ability in their daily life if opportunities are provided for them to experience the following:
  (1) how mathematical concepts and skills are developed in the contexts of problem situations
  (2) how newly learned concepts and skills may be useful in solving problems with the same structure or may be transferred to accommodate novel situations, and
  (3) how specific strategies may be applied to solve problems.

Furthermore, problem solving can be viewed in three ways. One way is *teaching and learning mathematics through problem solving.* This view uses real life situations or mathematical problems to develop the concepts or topics and skills to be learned. Another way is *teaching and learning mathematics for problem solving.* In this view, the concepts, skills, and processes are first taught and learned by the students to enable them to solve real life or mathematical problems. The third way is *teaching and learning about mathematical problem solving.* In this view, the students are taught the different steps in solving a problem and the strategies for coming up with the solution.

- **Reasoning**

Based on the mathematical relationships that they observe, students should be able to make, verify and justify conjectures. Likewise, they should have the ability to provide convincing arguments or counterexamples to support the claims that they make. Moreover, on the basis of patterns that they discover, they should be able to make generalizations.

- **Communication**

The students should be able to understand and represent the meaning of a mathematical idea expressed in different forms, for example the geometric interpretation of algebraic formulas. They should be able to explain their ideas logically, clearly, concisely and accurately using concrete objects such as models or semi-concrete objects such as pictures or diagrams, in words verbally or in writing, and symbolically such as using graphs or equations.

- **Connection**

The students should be able to relate what they have learned to topics within mathematics as well as to disciplines outside mathematics, in a particular class level and across different class levels. They should also have the ability to apply their mathematical knowledge and skills in solving daily life problems. Furthermore, they should be capable and confident in using technology to solve problems and verify if their solutions are reasonable.

Learning Outcomes

- Conceptual understanding

It is important that students understand a concept thoroughly and this can be ensured partly by their consciously monitoring their own learning. For instance, when students forget mathematical rules or procedures, they can always rely on their clear understanding of concepts to help them reconstruct these rules or procedures.

- **Thinking Skills**

In the process of doing mathematics, students use different thinking skills The 2003 Assessment Framework of the Trends in International Mathematics and Science Study categorizes into four, the cognitive domain which includes various thinking skills. These categories provide a useful scheme that encompasses the different levels of thinking. Some examples of these thinking skills are:

- Classifying
- Representing
- Formulating
- Interpreting
- Applying
- Verifying
- Making conjectures
- Predicting
- Analysing
- Generalizing
- Connecting
- Synthesizing/integrating
- Justifying/proving

- **Manipulative/Procedural Skills**

  - Using mathematics instruments for measuring, calculating, and constructing geometric figures
  - Arithmetic, algebraic and statistical manipulations and calculations and geometric constructions

- **Dispositions: As the students do mathematics, the following dispositions should be developed:**

  - Curiosity (spirit of discovery and exploration)
  - Interest/Appreciation
  - Confidence
  - Perseveranc

Guidelines for Reviewing the Curriculum

The considerations for making the framework were also used to formulate the guidelines for reviewing the curriculum. The criteria for the review of the Mathematics curriculum for classes VI to X are shown below:

1. Is the curriculum in line with the objectives of the national education policy?
2. Does it cover the latest developments in Mathematics?
3. Are the topics sufficiently covered time-wise for the specified class?
4. Do we need to delete any topics?
5. Do we need to add some new topics?
6. Is there a need for horizontal adjustments?
7. Is there a need for vertical adjustments?
8. Is the curriculum comparable with the curriculum of advanced countries?
9. Does the curriculum satisfy the educational needs of the students?

A questionnaire that was intended to solicit a quick evaluation of the curriculum by those who were judged most capable was developed using the guidelines as basis. The brief rationale, reasons for the choice of the respondents and instructions for the instrument administration as well as the names of the respondents are found. There were a total of 14 respondents. The data gathered were used to supplement the independent review results of the Team members.

Findings and Recommendations based on the Review of the Mathematics Curriculum for Classes VI to VIII

Using the framework and the guidelines, there are common findings that emerged from the review of individual topics in the mathematics curriculum for Classes VI to VIII. These findings and the recommendations that correspond to them are given below.

Problem Solving

Findings:

Real life situations apparently referred to as word problems in the curriculum are not explicitly required to introduce concepts or skills even when these can

naturally and logically be done. Most of the uses of problem solving in the curriculum appear to be teaching and learning for problem solving. Thus, the kind of problems can expectedly be just the routine ones, those that are similar to what will be presented in the textbook or taken up in class. As such, the learners will already know the procedures for obtaining the solutions or answers.

Recommendations:

The curriculum should offer a full range of problem solving experiences. Teaching through problem solving will provide the students opportunities to contend with non-routine problems. These are unfamiliar situations needing solutions for which students do not have readily available algorithms or prescribed procedures to use. With such, the potential for the development of high-level thinking is great.

Computational exercises or manipulation of symbols should be in the context of real life problem situations so that the students will find learning mathematics meaningful and relevant. Students will see that school mathematics is related to the mathematics outside the school.

Reasoning

Finding:

The basis of a procedure or rule and the reasons why a procedure or rule works are not required. And so, the approaches to teaching and learning that rely primarily on the textbooks which are based on the curriculum may likely be very mechanical, conducive to memorization and imitation, and characterized by superficial understanding. Rote learning does not encourage critical thinking.

Recommendation:

The curriculum should require that underlying reasons for commonly accepted mathematical procedures or relationships expressed in formulas be explained adequately and clearly.

Connection

Finding:

There are gaps as well as overlaps in the topics introduced within a class level and across different class levels. Sometimes a topic is presented without the necessary required knowledge or skills There are also instances when a comprehensively developed prior knowledge or skill is not at all used in subsequent topics. Some topics are developed in higher class levels as if the students are encountering them for the first time when in fact they have been just as well introduced in the lower class levels.

Recommendation:

Strengthen the vertical and horizontal articulation of the topics in the curriculum.

Finding:

Using calculators when they are available and needed is not at all mentioned in the curriculum. The power of this technology in aiding student investigation of mathematical relationships such as number patterns or in enhancing their reasoning skills when they make estimates is not taken advantage of.

Recommendation:

Provide for the appropriate use of calculators (and if possible, even of computers) if such technology is available.

Thinking Skills and Dispositions

Findings:

Nowhere in the curriculum is there any mention of the importance to develop among students thinking skills such as making conjectures and predictions, generalizing, and justifying. Likewise, there is no reference at all of the need to develop student dispositions such as interest in mathematics and confidence in doing it.

Recommendation:

The curriculum should explicitly mention as part of its objectives, the development of thinking skills and desirable dispositions among students. This way, textbook authors and teachers will be aware that this is just as important as students' learning mathematical content. Hopefully, they will exert efforts to make this happen.

Content

Finding:

Certain topics, which are covered in the curriculum of countries like Singapore and the United States of America are not found in the curriculum. These include problem solving strategies (e.g. guess and check, working backwards, simplifying a problem), symmetry, number patterns, geometric patterns, and concepts of chance or probability.

Recommendation:

The curriculum should consider including topics such as problem solving strategies, symmetry, number patterns, geometric patterns, and probability.

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