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Reform, Revolution and Paradigm Shifts in Mathematics Education
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Reform, Revolution and Paradigm Shifts in Mathematics Education Some Examples and Applicable Strategies

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The major aims of this paper are: To present paradigm shifts in mathematics education and their implications on the area, to analyze some attempts to implement them and to suggest some applicable strategies to bridge the gap between "theory and practice".

Paradigm shifts in the area lead to many trends in mathematics education, such as: Concentrating on developing creativity, integrated curricula, introducing major changes in the teaching and evaluation processes, employing "complexity" in dealing with different issues, using advanced technology in learning and teaching processes.. etc.

The examination of relevant educational materials show that, when these materials are fully applied, there are some models, may be some steps, to be used in developing mathematics education. Nevertheless, there still exists a gap between them and " theory ".

The study is concluded by suggesting some alternatives to those suggested trends in order to bridge the gap between theory and practice, at least in long term.

Introduction

It seems that the real problem is not related to identifying paradigm shifts in mathematics education. It is rather related to the procedures taken to put these shifts into practice. Many educational systems have attempted some reforms in the area of mathematics education, may be revolutions, but still a gap exists between " theory and practice ", sometimes are due to the whole system of education and other times are due to choices of teachers and parents.

The major aims of this paper are: To present paradigm shifts in mathematics education and their implication on teaching/learning mathematics, to analyze some attempts to implement them [(1)], and suggest some applicable strategies to bridge the gap between "theory and practice".

Needless to say, mathematics education is a sub-system of the whole curriculum in a society, which is -in its turn- a sub-system of the educational system in such a society, the societal conditions, as well as the regional and humanistic cultures (including the process of globalization).

Paradigm Shifts in Mathematics Education and their Implications on Mathematics Education

These shifts are based on the paradigm shift in the area of mathematics from seeing mathematics as the study of formal systems to seeing mathematics as a living body [(2)]. This shift has been reflected in primary school mathematics programmes "from seeing mathematics as a large collection of concepts and skills to be mastered in some strict partial order to seeing mathematics as something people do [(3)], and in secondary school mathematics programmes from the "formal" teaching of mathematics to introducing mathematics as human activity in order to provide a basic preparation of learners for full participation as functional members of society [(4)].

Keeping in mind recent developments in science [5] and the whole globe[6], it seems that paradigm shifts in mathematics education could be reflected in the area as follows [7]:

1- The aims of education are basically: Developing creativity, making the study enjoyable and preparing students to deal with future trends both in knowledge and careers.
2- Concentrating on conceptual bases with very little attention to computations, as with the use of calculators and computers.
3- The study is almost to be in integrated contexts.
4- Emphasis is given to stating assumptions behind different formulas, the existence of different possible solution and to "commons" among different systems.
5- Multiple curricula are to be taught, may be provided to individuals or groups, being based on multiple intelligences theory.
6- No "traditional" formal teaching is provided, while encouraging students to "theorize" for themselves.
7- Intensive use of technology with emphasize on data collecting, building knowledge and self-learning.
8- Evaluation is mainly continuous and non-formal, with great attention to self-evaluation and discussion of student's reports and "research work".
9- Programmes of pre- and in-service teacher education will be professionalized, while employing non-traditional methods and means of evaluation in both programmes.
10- Teacher organizations will have the first say in curriculum adoption as well as school practices.

Results of the Analysis

The results of analysis of the studied materials can be summed up as follows [8]:

(1) Apart from MISP publications and theses' suggestions, no material can be described as "integrated". Many of the used text-books are providing real life examples and applications in life, to different degrees. Nevertheless, many of them are not used in the classroom, for different reasons.
(2) There is still a wide range world debate on the use of calculators in arithmetic operations in primary education.
(3) Many of mathematics curricula, especially in Canada and the United States of America are based on the use of technology, particularly graphical calculators and computers.
(4) There is a distance in some of the analyzed text-books from the formal teaching of mathematics, but others used it, may be devoting some chapters to "proof" …etc.
(5) Some schools adopt the "multiple intelligences theory" as base to their curricula, but most schools, even in developed countries, are far away from the application of this theory.
(6) The status and influence of teacher organizations in school matters differ in different countries.
(7) There is – almost - a gap between teacher education programmes and the intended school of the future.
(8) Evaluation, as well as systems of university admission, could be considered as the weakest point in most countries.

Applicable Strategies

It must be referred to that many strategies mentioned below are in sense of alternatives to those mentioned in the second part of this paper [9] and that the applicability of many of them depends on the size of changes in systems of evaluation and the whole educational system.

The most important of these applicable strategies are as follows (10):

a) Mathematics is still to be taught as a separate syllabus, but greater attention is given to the application of mathematics in life and other disciplines, and to mathematical modelling.
b) Attention is increasingly being given to stating assumptions behind different formulas (particularly when adopting the linear model), the existence of different possible alternative solutions to many problems and realizing "common features" among different systems.
c) Using both manual operations and calculators in primary education.
d) A gradual decrease of the use of the traditional formal teaching of mathematics.
e) Dealing with some levels of "curricula", may be by means if using different materials and/or test-books.
f) Using technology, to some extent, in the learning/teaching processes, with growing emphasis on collecting data and self-learning.
g) A great deal of interest to be given to continuous and non-formal evaluation, side by side with final written examinations, mostly by the end of educational stages, to include different cognitive levels.
h) Introducing major changes in mathematics teacher education, whether pre- or in-service education. We suggest "professionalization" of pre-service training and concentrating on the use of non-traditional methods of teaching mathematics in in-service education (11).
i) A greater role to be given to mathematics teachers organization-in their different forms –in changing and controlling school curricula.

Needless to say that the above mentioned alternatives are applicable- if needed- in different degrees and forms in different countries.

Notes

(1) The analyzed materials include :

a) The MATHDOWER™ series (for Grades 7-12 Western Edition), written by different authors, 1996-1998), and published in Toronto by McGraw-Hill Ryerson Limited.

b) A group of different American text-books in secondary education, including the following:

i) Larson, Roland E., Kanold, Timothy D. and Stiff, Lee (1998). **Algebra 1; An Integrated Approach.** Evanston, Illinois: McDougal Littell.

ii) Serra, Michael (2003), **Geometry; An Investigative Approach,** Third edition. Emeryville, California : Key Curriculum Press.

iii) Foerster, Paul A. (2003), **Precalculus with Trigonometry; Concepts and Applications**. Emeryville, California: Key Curriculum Press.

c) MISP series :

Alan Rogerson / and Andy Gamble (1995-1999), published in New Zealand by User Friendly Resource Enterprises Limited.

d) Some PhD theses dealing with mathematics in primary education, including:

Lashin, Samar (2004). "Constructing a Curriculum in Mathematics for the Hearing Impaired Students at the Primary Stage in the Light of the Contemporary Changes in Teaching Mathematics', Unpublished PhD Thesis, Faculty of Education, Ain Shams University (In Arabic).

Ahmed, Monier (2004). "A Suggested Model for Integrating Mathematics Curricula with other Subjects for the First Stage of Basic Education in Palestine", Unpublished PhD Thesis, Faculty of Education, Ain Shams University (The Co-operative Programme with Al Aqsa University, Gaza) (In Arabic).

(2) See for Example:
Ernest, Paul (1992). "The Revolution in the Philosophy of Mathematics and its Implications for Education". In: Christopher Ormell (Ed.), **New Thinking about the Nature of Mathematics** (pp. 33-38). Norwich: MAG-EDU, University of East Anglia.
Mina, Fayez M. (November 2000). "Theorizing for Non-theoretical Approaches in Mathematics Education". In: Alan Rogerson (Ed.), **Proceedings of the International Conference of Mathematics Education into the 21st Century Project on "Mathematics for Living"**, Amman, Jordan, November 18-23, 2000, pp. 6-10.
Rogerson, A. (1986). "Mathematics in Society Project: A New Conception of Mathematics", **INT.J. EDU. SCI. TECHNOL**., 17(5), pp. 611-616.
(1999). "Innovative Challenges for Mathematics Education in the New Millennium (Some User-friendly Ideas and Quotations)". In: Alan Rogerson (Ed.), **Proceedings of the International Conference of Mathematics Education into the 21st Century Project on Societal Challenges, Issues and Approaches"**, Cairo, November 14-18, 1999, pp. 6-11.

(3) Romberg, T.A. (1994). "Mathematics: Primary School Programs". In: Torsten Husén and T. Neville Postlethwaite (Eds.), **The International Encyclopedia of Education,** Second edition (pp. 3655-3661). Oxford: Pergamon Press. p.3655.

(4) Travers, K. (1994). "Mathematics: Secondary School Programs". In: Husén and Postlethwaite, ibid (pp. 3661-3668). P.3661.

(5) See: Mina (November 2000), Op cit.

(6) See:
Mina, Fayez M. (2004). "Some Remarks on the Future of Mathematics Education". In: Alan Rogerson (Ed.), **Proceedings of the Seventh International Conference of the Mathematics Education into the 21st Century Project on "The Future of Mathematics Education",** Ciechocinek (Poland), June 26 – July 1st, 2004, pp. 93-97.

(7) See: Ibid.
Note that the mentioned items are almost those representing the "extreme" positive future trends in mathematics education.

(8) The studied materials are those mentioned in note no.(1).
It must be referred to that the author has used his experiences, school visits and "asking people" in some of his judgments in this section.

(9) Under the title "Paradigm Shifts in Mathematics Education and their Implications on Mathematics Education".

(10) See:Mina (2004), Op. Cit.
Mina, Fayez M. (2001). "Prospective Scenarios for Mathematics Education Around the Year 2020". In: Alan Rogerson (Ed.), **Proceedings of the International Conference of the Mathematics Education into the 21st Century Project on "New Ideas in Mathematics Education",** Palm Cove, Queensland, Australia, August 19-24, 2001, pp176-179.

(11) Professionalization means that teaching and learning in programmes of pre-service teacher education should be conducted in an atmosphere comparable to what ought to be at school in its ideal form, in relation to analyzing and teaching particular curricula. Also, intensive discussions and analyses of the reality of schools, curricula and teaching, and the role of the teacher in developing them are essential to teacher education in this context.
In service teacher education should support the growing trends in mathematics education including the use of self-education, dialogue, brain-storming, assignments, advanced technology … etc.

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