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Professional Development of Mathematics Teachers[1]

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In the present paper we highlight the importance and need of professional development of mathematics teachers at all levels. The pre-service professional development and technology proficiency of mathematics teachers are discussed in details. New strategies for professional development are enlisted for discussion and a list of references is also given in the end.

Keywords: professional development; teaching standards; teaching methods; prospective teachers; technology proficiency.
ZDM Classification: B50
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1. INTRODUCTION

"You can't teach what you don't know," but too many of our mathematics teachers may be doing exactly that they are teaching what they do not know. They are not well equipped with knowledge and skill of teaching mathematics. During my more than forty years teaching experience from school level to university the author have realized that mathematics learning depends on how and who teaches it. The only way to achieve better mathematics education is to have better mathematics teachers who have the ability to conduct workshops and facilitate group discussions, create professional development activities for colleagues in the school whilst acknowledging the school's context and culture. So there is intensive need of professional development of mathematics teachers especially for

(a) Those who teach mathematics without proper training.
(b) Those who did not acquire the requisite mathematics content knowledge.

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(c) Those who do not take advantage of technology in teaching mathematics.

Thus it becomes imperative to discuss the reasons and remedies of such problems. In the present paper we make a passing comment about (a), while we discuss the other two issues (b) and (c) in sections 2 and 3 respectively.

Globalization has profoundly affected the teaching and learning in mathematics. It has shaped what is being, the use of technologies in the classroom, the connectivity between the professors and the institutions nationally and internationally, the conditions of academic facilities, the relationship between knowledge production and the market, and the lives and interactions of students faculty. State governments, private educational societies and corporations appoint mathematics teachers in middle and high schools temporarily or on ad-havoc basis. These teachers have no proper training in methodology and technique for mathematics teaching. Doing mathematics is a skill that requires an intensive training; however, remedial summer schools can be organized for the benefit of these teachers.

2. PRE-SERVICE PROFESSIONAL DEVELOPMENT

There are many ways to explain why so many mathematics teachers perform poorly the classroom. One obvious reason is that they never learned the subject properly all the way from primary school to college. This then precludes the possibility of good teaching because one cannot teach what one does not know. Another explanation of teachers' poor performance is that their stilted, constricted and rigid approach to the subject.

In most cases, these teachers have never seen any kind of mathematics teaching other than their teachers, and professors' equally stilted, constricted and rigid style all through school and colleges. Years and years of exposure to bad teaching naturally takes its toll. Theoretically, such flaws in one's teaching would be eliminated in classes on pedagogy in the school of education, but this theory fails due to the following two reasons (Wu, 1999):

1. That undoing this kind of pedagogical problem requires a deep knowledge of the subject on the part of prospective teachers and their instructors alike.
2. That one cannot undo the harmful effects of years and years of direct observations of bad teaching in one or two semesters. So a starting point of pre-service Professional Development has to be better teaching across the board in colleges and even in schools.

Content knowledge of mathematics includes the knowledge of how mathematics is usually done *i.e.* the unending trials and errors, the need to search for concrete examples and counter examples to guide one's intuition, and the need to make wild guesses as well as subject these guesses to logical scrutiny. This knowledge is indispensable to effective teaching because it has direct impact on class representations, problem solving, and assessment of students' work. Without this knowledge, a teacher can't help but make students believe that problems are solved by sitting down, meditating, and waiting for perfect solution. Due to this misconception about mathematics classroom presentations come like textbook at the board.

Schoenfeld (1988) has described this kind of teaching as bad teaching and badness has little to do with failure of pedagogical technique and every thing to do with the lack of mathematical content knowledge. We believe one achievement of the recent reform is to make professors realize that most students do not learn mathematics without being shown, step by step, how it is done in many concrete cases. A key emphasis in professional development, pre-service or in-service, therefore, has to be on exposing teachers to the process of doing mathematics.

Some people believe that what is needed in mathematics professional development at this juncture is sequel to "A Call for Change" (Leitzel, 1991) and the NCTM Teaching Standards "Professional Standards for Teaching Mathematics" (National Council of Teachers of Mathematics, 1991).

However, it can be viewed that NCTM document has misled its readers by not making an explicit statement to this effect anywhere. With regard to the mathematics education reform, such a reference to content knowledge is all relevant because the new pedagogical practices advocated by the reform — the discovery method and the spontaneous dialogue between students and teacher — require mastery of the subject.

In the context of the mathematical education of teachers, a report authored by Alan Tucker *et. al*, published in the Mathematical Education of Teachers by the Conference Board of Mathematical Sciences in 2001 is referred. This report is designed to be a resource for mathematical faculty and other parties involved in the education of mathematics teachers. It is a distillation of current thinking on curriculum and policy issues affecting the mathematical education of teachers, and stimulating efforts on individual campuses to improve programs for prospective teachers. It is also intended to marshal the backing of the mathematical sciences community for important national initiatives, such as the use of mathematics specialists to teach mathematics starting in middle grades and expanded time for professional development in schools.

Finally, it is debatable what mathematics should be taught to prospective teachers. There is perhaps no better way to demonstrate what a serious document on the teaching of mathematics can do in the way of underscoring the critical role of content knowledge in teaching than to cite one that does this surpassingly well. Ma (1999) has shown in the most befitting manner that without a profound understanding of fundamental mathematics, it is impossible to be a competent mathematics teacher in K–5. On page after page she illustrate with concrete examples of how teachers with deficient understanding of some basic mathematical topics mangle their answers or explanations to innocuous questions that arise in the classroom. Her main conclusion is as follows:

> "Having considered teachers' knowledge of school mathematics in depth, I suggest that to improve mathematics education for students, an important action that should be taken is to improve the quality of their teachers' knowledge of school mathematics."

Other educators, especially Deborah Loewenberg Ball[2], have also supported and advocated this point of view (*cf.* Ball, 2000; 2002; Ball & Cohen, 2000; 2006).

3. TECHNOLOGY PROFICIENCY FOR MATHEMATICS TEACHERS

In recent years teacher preparation is emerging as a critical factor limiting the contributions of new technologies to improved learning. Central and state governments and local agencies are investing heavily to equip schools with computers and modern communication networks. If our information technology investments are to pay off in improved education, these future teachers must be technology-proficient educators who should know how to use these modern learning tools to help students to meet high standards. The following excerpt from the "Technology and the New Professional Teacher: Preparing for the 21st Century Classroom" (National Council for Accreditation of Teacher Education, 1997) illustrates the need for pre-service reform:

> "To what degree is higher education institutions meeting their responsibility for preparing tomorrow's classroom teachers? Bluntly, a majority of teacher preparation programs are falling far short of what needs to be done. Not using technology much in their own research and teaching, teacher education faculties have insufficient understanding of the demands on classroom teachers to incorporate technology into teaching. Many do not fully appreciate the impact technology is having on the way work is accomplished. They undervalue the significance of technology and treat it as merely another topic about which teachers should be informed. As a result, colleges and universities are making the mistake that was made by K–12 schools; they treat 'technology' as a special addition to the teacher education curriculum-requiring specially prepared faculty and specially equipped classrooms-but not a topic that needs to be incorporated across the entire teacher education program. Consequently, teacher-in-training are provided instruction in computer literacy and shown examples of computer software, but they rarely are required to apply technology in their courses and are denied role models of faculty employing technology in their own work".

Teaching activities in mathematics should take advantage of the capabilities of technology, and hence should extend beyond or significantly enhance what could be done without technology. Technology enables users to explore topics, *e.g.*, interconnect

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[2] http://www-personal.umich.edu/~dball/

mathematics topics, write programs, and devise multiple proofs and solutions in more depth and interactive ways. Technology also makes accessible the study of mathematics topics that were previously impractical, such as recursion and regression, by removing computational constraints.

Technology-based activities will facilitate mathematics connections in two ways:

(a) interconnect mathematics topics and
(b) connect mathematics to real world phenomena.

Technology "blurs some of the artificial separations among some topics in algebra, geometry and data analysis by allowing students to use ideas from one area of mathematics to better understand another area of mathematics" (NCTM, 2000, p. 26). For example, students can investigate the connections between geometric and algebraic representations is with infinite series. Many school mathematics topics can be used to model and resolve situations arising in the physical, biological, environmental, social, and managerial sciences. Many mathematics topics can be connected to the arts and humanities as well. Appropriate use of technology can facility such applications by providing ready access to real data and information, by making the inclusion of mathematics topics useful for applications more practical e.g., regression and recursion, and by making it easier for teachers and students to bring together multiple representations of mathematics topics. This guideline supports the curriculum standards of NCTM (1989; 2000).

It is a challenge for teachers at all levels to bring concepts alive for their students, and to engender excitement about the technology tools used to facilitate data representation and communication. In 2001 Center for Research in Mathematics and Science Education, North Carolina State University, U. S. introduced a teacher training process in which participants actively engaged in investigations that integrate information technologies into teaching and learning of mathematics. These investigations can be used in both teacher training and in the classroom. The approach has several advantages: Mathematical concepts are introduced through relevant technology-enhanced problem investigations, engaging participants in defining and solving problems. Group interactions promote creativity and variety in ideas and approaches. Participants learn to present ideas in computer-based, multimedia formats. In addition to these advantages, the training process is a model for the small-group learning in process that students will experience and is thus an experience in modeling for teachers. The process also prepares participants to formulate similar instructional techniques of their own.

Generally, students and teachers in teaching and learning of mathematics use audio-visual/multimedia, calculators and computers. Out of this computer technology has found wide applications. In this context we refer to research information from the national survey (Anderson & Ronnkvist, 1999; Becker, 1998), a study of teachers' use of computer technology, their pedagogies, and their school context. More than 4000 teachers and related technology coordinators and school principals participated in the study that included schools and teachers from a national probability sample and also included purposive samples of schools and teachers because of their participation in major science reform programs of their unusually high amounts of computer technologies available. Findings were released in 1999 and had addressed the questions such as...

- How are different uses of computers by teachers?
- How prevalent are different teaching philosophies and instructional practices?
- What is the relationship between how a teacher uses computers and their basic instructional beliefs and practices?
- What factors in their personal background and teaching environment, such as pattern of school expenditures on technology, social support for technology use, presence of school-wide reform efforts, and the teacher's own previous technology experience and educational background, distinguish among teachers who use computer technologies differently?
- How much do teachers believe that their computer experiences are changing practice in other ways, such as the kinds of assignment they give about how they interact with their colleagues and students?

TLC surveyed teachers from a national probability sample of schools and from targeted sample of schools-high and technology-using schools that participate in 52 identified national and regional educational reform programs. In conclusions it is mentioned that frequent use of computers by middle and high school teachers and their students in math., science, social studies, and English is still very much a rare phenomenon. Outside of word processing, very few teachers have their students make frequent use of computers during class. Students in lower-ability classes are often given computer games and drills related to the subject area of their class, but it is primarily those rare classes of other students and other teachers who use more sophisticated computer software as resources and tools for doing productive and constructive academic work. The teachers' philosophy of education certainly plays a role in determining whether he/she will use computers and how they will be used, but there are even stronger factors at work in determining whether teachers will make use of computers during class time for constructivist learning approaches. Those strong factors are the teachers' own technical expertise and professional experience in using computer applications, the number of computers in their own classroom, and their personal involvement in their profession, both within their school building and beyond. Each of those factors appears to be stronger determinants of constructivist uses of computers during class than the teacher's philosophy.

4. NEW STRATEGIES FOR PROFESSIONAL DEVELOPMENT

Professional development does not occur as an isolated strategy. Every program uses a variety of strategies in various combinations. There are five different models of effective professional development for teachers, which can be used singularly or in combinations. These have been identified: training, individually guided staff development, observation/assessment, involvement in development process, and inquiry (refer Lee, 2001). Loucks-Horsley *et al.* (1998) discussed specific professional development strategies (learning experiences) with different purposes indicated by Brown & Smith (1997). These strategies correspondent to the professional development models are adopted by several different institutions or organizations. For the primary purpose of building teacher knowledge, recommended strategies are: engaging in the kinds of learning that teachers are expected to practice with their students; participating in workshops, summer or winter institutes, courses, and seminars; interacting in person or through electronic means with other teachers to discuss topics of common interest; and using various kinds of technology to learn content and pedagogy.

It is suggested to create new instructional materials and strategies to meet the learning needs of students. For the best effect of these strategies it requires voluntary participation, clear expectation, an established procedure, content knowledge, and district or school administration support are important. Strategies related to teaching practice include curriculum implementation, curriculum replacement units, working with experienced teacher to improve teaching and learning through a variety of activities.

We can use action research, case discussion, examining students work, and study groups as the strategies for the promoting reflection. To achieve desirable outcomes when using these strategies, access to research resources, time, administrative support and atmosphere conducive to experimentation and opportunities to share the results of their research should be taken in view.

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