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Theoretical Consideration of the Components of Preservice Mathematics Teacher Training

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This research elaborated five components for pre-service mathematics teacher training:

1) Mathematical content knowledge,
2) Pedagogical content knowledge,
3) Pedagogical reasoning,
4) System of training, and
5) Mathematics teachers' beliefs.

For the effect teaching, mathematics teacher program should be reformed. The key to improvement should be concentrated on developing knowledge about effective teaching and translating it into algorithms those teachers can learn and incorporate in their planning prior to teaching. A theory of instruction must specify the ways in which a body of knowledge should be structured so that most readily grasped by the learner. A theory of instruction should specify the most effective sequences in which to present the materials to be learned.

INTRODUCTION

Preparation for teachers of mathematics is one of the critical issues in mathematics education. However, educators did not much pay attention to the issue. National surveys of teachers indicate that they generally believe that their teacher education programs did not prepare them adequately for teaching school mathematics (Bush, 1986, p. 21). The vast majority of what passes for teacher preparation makes little effort directly or indirectly to provide preservice and inservice teachers with precise professional, intellectual, affective, or psychomotor skills called for in surveys, by scholars or as a result of research on teaching (Cruickshank & Metcalf, 1990, p. 475). Teacher education program is still carrying the stigma of requiring students to absorb dull and irrelevant theory that offers little assistance to the budding practitioner (McBride, 1985, p. 23).

Teacher candidates and experienced teachers alike tend to see course as 'theoretical' by which they generally mean 'vague and impractical' (Darch, Carnine & Gersten, 1988, p. 35). Generally, preservice teachers are not much trained for qualifying capable teachers. Mathematics teacher education program still persists their own conservative methods that developed in 19th century to decorate 21st novice teacher. Therefore, we need a progress for teacher education program. We need a solution for the issue that cultivates competency teachers. Brown and Borko (1992) also pointed that improvements are needed in teacher education.

> Neither current academic nor current professional educational coursework are particularly good at helping prospective teachers develop high literacy in their content areas improvements in both should be the focus of teacher education reforms (Brown & Borko, 1992, p. 221).

In mathematics education. Polya advocated radical changes in preparing teachers since the early 1960's, however, his ideas are only now being reflected in reform efforts (Kilpatrick, 1987). The reform imbedded into the efforts of the *National Council of Teachers of Mathematics* (NCTM). NCTM has developed guides for the content and pedagogy of teachers through the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), the *Professional Standards for Teaching Mathematics* (NCTM, 1990) and Principles and *Standards for School Mathematics* (NCTM, 1999). These sets of standards provide a direction, but not the mechanism, for reform in school mathematics. However neither NCTM document is well grounded in systematic research, although these are widely accepted as guidelines representing the mathematics education community's one of the best ideas on these topics. More specific structure of mathematics teacher program should be constructed which enriched by content-oriented curricula that can make a critical impact on the teaching mathematics in natural settings.

We should count on what we need and what we should prepare for new generations. This research tries to elaborate several components for preservice mathematics teacher training to support for reforms of the mathematics teacher education.

COMPONENTS FOR PRESERVICE MATHEMATICS TEACHER TRAINING

This research on mathematics teacher education will suggest five areas of recommendations toward the mechanism of reform in training mathematics teachers. The five aspects of mathematics teacher education are: content knowledge, pedagogical content knowledge, pedagogical reasoning, training, and beliefs.

Content knowledge consists of an understanding of the key facts, concepts, principles and explanatory frameworks in a discipline, as well as the rules of evidence and proof within that discipline (Shulman & Grossman, 1988). Polya used a mix of subject matter and methods which was roughly 9:1 (Kilpatrick, 1987), indication the importance he placed on subject matter. According to Ball (1990), subject matter knowledge should be a central focus of teacher education programs. Borko, Eisenhart, Brown, show a research result that a preservice middle school mathematics teacher with more than the recommended number of courses in mathematics. The preservice teacher demonstrated a lack of conceptual knowledge in mathematics. Brown & Borko (1992) describe several studies which suggest that an increase in subject matter knowledge for preparing mathematics teachers is essential. Findings include strong subject matter knowledge enabling novice teachers to plan more productively, lack of subject matter knowledge hindering the transition to pedagogical thinking, and increased content knowledge enabling teachers to connect topics, provide more conceptual explanations, and focus more on problem solving.

Although mathematics education majors take courses in both mathematics and mathematics education, conceptual understanding of the content is typically not stressed, and even when a course focuses on concepts, students regularly do not make conceptual understanding explicit enough to challenge previous algorithmic constructs of mathematics (Borko et al., 1992). This kind of cognition for knowledge is very dangerous for teachers to teach students, because they cannot explain the mathematical solution that fits for the problem situations. Ball (1988) explains that to teach mathematics effectively, individuals must have knowledge of mathematics characterized by an explicit conceptual understanding of the principles and meaning underlying mathematical topics, rules, and definitions.

Pedagogical content knowledge, or subject-specific pedagogical knowledge consists of an understanding of how to represent specific topics and issues in ways that are appropriate to the diverse abilities and interests of learners (Borko et at., 1992, p. 196). Polya described pedagogical content knowledge as 'know-how'. Mathematical know-how is primarily the ability to formulate, solve, and critically reflect on problems (Kilpatrick, 1987, p. 87). Brown & Borke (1992) contend from their survey of research that pedagogical content knowledge, the one domain of knowledge unique to the teaching profession, is relatively undeveloped in novice teachers. Preservice teachers attribute methods courses as the primacy influence of pedagogical content knowledge (Bush, 1986). Implications from research suggest that methods courses should make pedagogical content knowledge a central priority (Brown & Borko, 1992).

Cruickshank & Metcalf (1990) suggest that pedagogical content knowledge can be analyzed to determine specific behaviors that the teacher must attain. Their review of research indicates that training teachers to put pedagogical content knowledge into application can produce positive results.

Pedagogical reasoning also is very important factors for teaching mathematics.

> The process of transforming content knowledge into forms that are pedagogically powerful and adaptive to particular groups of student...making the transition from a personal orientation to a discipline to thinking about how to organize and represent the content of the discipline to facilitate student understanding (Brown & Borko, 1992, p. 221).

Feiman-Nemser & Buchmann (1986) identify the transition to pedagogical reasoning as a major component of learning to teach. They found that preservice teachers find it difficult to make that transition. They recommend that teacher educators take an active role in guiding preservice teachers pedagogical reasoning by demonstrating teacher actions and decisions (Feimen-Nemser & Buchmann, 1986).

In the case study by Borko et al. (1992), the student teacher focused on classroom management. Her use of activities and applications in the class was not to facilitate student understanding, but to maintain student interest and avoid management problems. Fuller and Brown (1975) describe the transition to pedagogical reasoning as going through four developmental stages: preteaching concerns, self-concerns, task concerns, and pupil concerns. Teachers will not develop concerns about pupils or their understandings until teachers have resolved concerns about their own survival and teaching situation

This statements means that teacher education program should focus on the actual challenge that teachers will face in the classroom in order to develop pedagogical reasoning. Lanier & Little (1986) indicate that teacher education should also enculturate preservice teachers in a standard pedagogical method such as described by the NCTM documents by having university programs, cooperating teachers for student teaching, mentors for beginning teachers, and colleagues all supporting those documents. Unless novice teachers experience good mathematics as students, see it modeled by teachers they respect, and are situated in a culture of teaching that accepts and practices good teaching, it will be difficult for them to implement and maintain good teaching in their classrooms (Brown & Borko, 1992, p. 227).

The practice of teacher training has endured harsh criticism from teacher educators in the current trend of constructivist theory in learning. Nonetheless, because training is an integral part of preparation for a profession and because it is possible to identify training needs, it becomes incumbent upon teacher preparation units and individuals therein to develop and implement appropriate training regimens (Cruickshank & Metcalf, 1990, p. 473). As they mentioned in that research, aspects of pedagogy content knowledge can be identified by specific behaviors that can then receive training. Some research discussed by Cruickshank & Metcalf (1990) includes teaching skills in changing the deviant behavior of students, in the use of discovery teaching, in understanding classroom communication, in becoming more reflective, and in becoming a better problem solver. Joyce (1988) claims that training can enable teachers to learn and control pedagogical skills that most novice teachers fail to learn.

The system of training described by Joyce (1988) combines four components:

1) The study of the theory and research of a teaching skill.
2) Demonstrations of the teaching skill.
3) Simulated practice of the skill, and
4) Self-feedback on skill acquisition.

Cruickshank & Metcalf (Cruickshank & Mekalf, 1990, p. 474) indicate research to substantiate fifteen principles for training.

1) Establish clear performance goals and communicate them to learners.
2) Insure that learners are aware of the requisite level of skill mastery.
3) Determine learners' present skill level.
4) Introduce only a few basis "rules" during the early learning stages.
5) Build upon learners' present skill level during early learning stages.
6) Ensure during the initial acquisition stage, a basic, essential conceptual understanding of the skill to be learned and when and why it is used.
7) Demonstrate during the initial acquisition stage what final skill performance should look like, drawing attention to salient features of the skill or subskills, as in the case of clarity. Provide sufficient opportunity to learn and apply the feature labels to the demonstration.
8) Provide opportunity for learners to discuss the demonstration.
9) Provide sufficient, spaced, skill practice after understanding of the skill has been developed, in both sub skill and cumulative whole-skill acquisition.
10) See that practice of the skill is followed by knowledge of results.
11) Provide frequent knowledge of results early in the learning process that is more effective if given with less emphasis on response quantity than on quality.
12) Provide knowledge of results after incorrect performance of a skill, which is most important.
13) Delay knowledge of results when the learner is beyond the initial stage of learning, which can be as effective as immediate knowledge of results when performance is correct or good.
14) Provide for transfer of training that is enhanced by maximizing similarity between the training and the natural environment, over learning salient features of the skill, providing extensive and varied practice, using delayed feedback, and inducing reflection and occasional testing.
15) Provide full support and reinforcement for use of the skills in natural settings.

Central to the use of training is the idea that pedagogical skill and reasoning should be explicitly addressed. Polya's method of discovery teaching, though a relevant methodology for mathematics instruction, may not be effective for the multitude of skills needed to be learned in a mathematics methods course (Darch, Carnine & Gersten, 1984). Borko et al. (1992) described in their research that a preservice teacher was exposed to teaching for conceptual learning, yet in practice her knowledge of the topic in study, division of fractions, was based on explanations and representations she could remember by rote. The study suggestes that university course work must help develop the concepts and language to draw connections between representations, applications, algorithms, and procedures and permit the practice and reflection for the development of those components (Borko et al., 1992). The foundation of substantiated methods as found in mathematics teacher training research should encourage educators to make use of this system. As Brown, Cooney & Jones (1990) comment, embedded in much of the literature on expert-novice teachers is the implication that some form of training might make the difference. Joyce's (1988) second component for systematic training requires demonstration of the teaching skill. Rosenshine (1987, p. 35) describes modeling in the presentaion of new material as follows:

> Effective teachers elaborate the material by providing many examples, providing additional explanations, making the points explicit and vivid, and summarizing one point before proceeding to the next. When teaching the students a skill, the teacher models each step explicitly.

The importance in the modeling of instruction has been understood for some time. Kilpatrick (1987, p. 94) comments:

> Because such arts [problem solving and teaching] can be learned only by imitation and practice, teachers need to provide appropriate examples to be imitated followed by opportunities for practice.

Modeling is important in all aspects of teacher education, especially in the cooperating teacher of an internship (Brown & Borko, 1992). Bush (1986) advocates training for the cooperating teacher in developing skills in helping interns make good decisions. In a study by Book, Byers & Freeman (1983) 90% of the student group entering profession teacher education programs believed that their professional studies had little new to offer them. Borko et al. (1992, p. 220) concluded their study on preservice teacher education by stating:

> We must find ways to challenge their [preservice teachers'] fundamental beliefs about learning, teaching, and learning to teach.

Beginning teachers often revert to the teaching styles similar to those their own teachers used (Brown et al., 1990). Ball (1988) has suggested that teacher education programs must sometimes help participants 'unlearn' as well as to learn (Brown & Borko, 1992, p. 235). Preservice teachers do look to methods courses for guidance in learning to teach. Many expect a teacher education program to provide a 'methods notebook' from which they can find relevant representations and applications for their future instruction (Brown et al., 1990).

Many aspiring mathematics teachers have their beliefs about mathematics changed during a methods course, however, the new view does not always carry over to their teaching practice (Brown & Borko, 1992). Most of preservice teachers should develop strong beliefs that mathematics must be relevant and meaningful for their students. Generally, most preservice teachers often looked to the methods course as a source of knowledge for the meaning and relevance, yet as their internship progressed they became more dependent on their practice and the textbook as sources for their beliefs about mathematics teaching (Borko et al., 1992). Bush (1986) also found that novice teachers heavily rely on the textbook for making decisions. Bush (1986) and Borko et al. (1992) have recommended further research into changing preservice teacher beliefs. Meyerson (1977) found that causing doubt about students' beliefs could often help students analyze those beliefs and bring about change. This could be a clue to solve belief problems of mathematics teachers.

CONCLUSIONS

The instruction of aspiring mathematics teachers lacks theory as described in this study. The five categories of recommendations for a reform in mathematics education may provide a starting point for theory along with the standards for good mathematics as promoted by NCTM. It is tempting to accept a theory for instruction of mathematics teachers that ignores the body of research available. Polya's theory of the balance of teacher education that is 9:1 for subject matter knowledge and knowledge for teaching methods should be changed to 7:3 roughly. Teacher education program should provide teaching experiences rather than a description of teaching theory. Aspiring mathematics teachers need extensive experience with the concepts and connections of the mathematics they wish to teach.

Preservice mathematics teachers need pedagogical processes related to the mathematical concepts. Novice teachers need to move from concerns of self and survival to concerns of the students by being confident in skills enabling their pedagogical reasoning. Mathematics teacher training in specific teaching skills and the system of training should be developed in preservice teachers education program. Concern for preservice teacher beliefs about mathematics learning, teaching, and learning to teach must also be focused to improve the program.

As Brown et al. (1990) described, we know very little about the variety of teacher education approaches and even less about long- or short-range impacts of different styles of teacher education. This research concludes that teacher education programs should be furnished with verity elements that may facilitate the process of becoming a good mathematics teacher. Mathematics teacher education programs should provide how to design, implement, and study subject matter for teaching mathematics. Programs for teachers should incorporate those elements.

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