Preparing Elementary Teachers to Foster Functional Thinking

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Abstract: The professional development program that involved 15 teachers and their students implemented during 6 months. Functional thinking was used as a centerpiece of the program for work with teachers Grade 1-5. To track the process of change of teachers and understand the trajectories through which teachers develop, we used concern-based adaptation model (CBAM) as a methodology. The result of study showed teachers' significant process of change in stages of concern. increasingly their feelings and understanding about functional thinking progressed.

Key words: Algebra; concern; Elementary teachers; K-8; Functional Thinking; Professional Development.

INTRODUCTION

"The work of the NCTM algebra Working Group (NCTM & MSEP, 1998) and the Early Algebra Group (Kaput, Carraher, & Blanton, 2008) reflects recent efforts in which researchers collaborate to find ways to integrate algebraic reasoning throughout Grades K-12 "(Jacobs, 2007). Many studies have performed about how students engaged in algebraic thinking, but there is no systematic evidence about effect of professional development on teachers. This lack of awareness relation to professional development and engaging teachers with functional thinking is counted as a big vacuum. According to Blanton (2005) creating ability and robustness in teachers to develop children's algebraic reasoning requires a significant process of change in elementary teachers, because many elementary teachers see algebra as a set of "rules and they need to develop algebra "eyes and ears"."

Professional development program that we introduce in this paper, was an innovation program designed to support Grade 1-5 teachers' involvement in development functional thinking. The study was examined changes in teachers' thinking and practice that deduced from their participation in developmental program. We designed a questions: 1. How does implementation of professional development program focused on functional thinking impact teachers' concerns?

Literature:

Functional Thinking:
A number of different characterizations of algebra can be found in the mathematics education literature. One of the forms of algebraic reasoning takes involves function thinking. Blanton (2005) proposed that generalized arithmetic and functional thinking offer rich entry points to study algebraic reasoning. Kaput (2008), in content analysis of algebra, identified two core aspects of algebra, including: (A) Algebra as systematically symbolizing generalizations of regularities and constrains (B) Algebra as syntactically “guided reasoning and actions on generalizations expressed in conventional symbol systems, and stated that these two core aspect are embodied in three strands. Kaput (2008) identified one of these strands as "Algebra as the study of functions, relations, and joint variation". Principles and Standards for School Mathematics published by the National Council of Teachers of Mathematics [NCTM] (2000) documents that instructional programs in all grades should enable students to understand patterns, relations, and functions.

Smith (2008) describes functional thinking, as “representational thinking that focuses on the relationship between two (or more) varying quantities” and for which functions denote the “representational systems invented or appropriated by children to represent a generalization of a relationship among quantities”.

Our own work focuses on functional thinking. This is because of two reasons that we will discuss here:
First, "many of the difficulties that algebra and pre-algebra students experience are artifacts of their early mathematics instruction". Carraher, (2000). carraher (2000) stated that:” difficulties stem largely from:
1. A reliance on restricted problem sets (e.g. emphasis on change problems with few comparisons and missing addend problems in early arithmetic).
2. A focus on notation as a means for registering computations rather that for providing a description of what is known about a problem.
3. A focus on computation of particular set values rather than on relations among sets."

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According to Carraher (2000) 'students' difficulties are accentuated and prolonged by the stark separation between arithmetic and algebra. He argued that this separation cannot be adequately handled by programs designed to ease the transition from arithmetic to algebra. Many of the notational tools used in arithmetic can be presented in new ways. Carraher (2000) explores how this might be achieved with regard to the operations of addition, subtraction, multiplication, and division. Carraher (2006) designed proper activities and found that eight-and nine-year-old children can not only understand additive functions but also meaningfully use algebraic expression such as \( n \rightarrow n+3 \) and \( y=x+3 \).

On the other hand, according Carraher (1996) "fundamental to relation and transformation is the concept of function, a schema about how certain quantities relate, or are changed or transformed, to other quantities". The construction and use of function is considered to be central to most mathematical investigations and has been found to be notoriously difficult for most students at all levels of learning (Cuoco, 1995).

The study of the concept of change mathematically, is fundamental to understanding functions and higher levels of mathematics (e.g., calculus) that are based on it (NCTM, 2000). It not only serves higher levels of mathematics, but also assists in a better understanding of the processes of arithmetic (Warren & Cooper, 2001).

**Professional Development of Teachers:**

Effective professional development is considered to be the center of educational reform. Policy makers, boards of education, legislators, funding agencies and taxpayers all want to know if professional development makes a difference (Guskey, 1997).

Kieran (1992) noted: "there is scarcity of research emphasizing the role of the classroom teacher in algebra instruction" (p.395). There also exists a need for more effective models of how teachers interpret the learning process (Ball, 1997).

Heideman, (1990) states that:"The professional development of teachers goes beyond a merely informative stage; it implies adaptation to change with a view to changing teaching and learning activities, altering teacher attitudes and improving the academic results of students. The professional development of teachers is concerned with individual, professional and organizational needs".

**Concern- Based Adoption Model:**

The Concerns-Based Adoption Model (CBAM) is a conceptual framework and methodological that measures, describes, explains, and predicts probable teacher behaviors in the change process resulted from implementation of curricular and instructional innovation. What the CBAM does, actually, is give people a set of lenses through which to view and understand the change process. The model holds that people considering and experiencing change evolve in the kinds of questions they ask and in their use of whatever the change is. In general, early questions are more self-oriented. The CBAM is based on a number of assumptions about the change process:

1. Change is a process, not an event, and it takes time to institute change.
2. Individuals must be the focus if change is to be facilitated and institutions will not change until their members change.
3. The change process is an extremely personal experience and how it is perceived by the individual will strongly influence the outcome.
4. Individuals progress through various stages regarding their emotions and capabilities relating to the innovation.
5. The availability of a client-centered diagnostic/prescriptive model can enhance the individual's facilitation during staff development.
6. People responsible for the change process must work in an adaptive and systematic way where progress needs to be monitored constantly (Hall & Loucks, 1978).

The three principal diagnostic dimensions of the CBAM are: Stages of Concern (Soc), Levels of Use (Lou), and Innovation Configurations (Ic). These are tools of CBAM for measuring change.

The concept of "concerns" has been described as follows: “Depending on their personal make-up, knowledge, and experience, each person perceives and mentally contends with a given issue differently; thus there are different kinds of concerns” (Hall & Hord, 2001, p. 59). The Soc, based on assumptions 3 and 4 describes the progression of individual feelings, perceptions, and motivations that result from curricular and/or instructional change. The Soc reports an individual's concerns profiles at any point during an innovation (Hall & Loucks, 1978).

**MATERIALS AND METHODS**

Thirty teachers who have thought in first till fifth grade participated in staff development program during the 2010-2011 school year, and extended till summer 2011. In this paper, we will study concerns and behaviors of fifteen teachers. These teachers were student in master degree in elementary education. None of them has not been passed mathematics course in their college study.
Procedure of Staff Development Program:

 Teachers attended three hours, in instructional program including lectures, conferences, and workshops every week for six month. During the week, they were in touch with authors through online contact. Additional lectures have been organized, if it was necessary.

 We categorized functional thinking practices in 6 category included: Category A: Representing data as an input-output, t-table; Category B: Representing data graphically; Category C: Representing data as an ordered pair; Category D: Finding functional relationship attending Blanton and kaput' work (2005) and converse; Category E: Predicting unknown statues using known data; Category F: Identifying and describing numerical and geometric patterns. We chose and designed activities for each category.

 Dreyfus (1991) posited that the learning process proceeds through four states, namely, using one representation, using more than one representation in parallel, making links between parallel representations, and integrating representations and flexibly moving between them. This type of category assists teachers to make multiple representations and support their learning.

 During the first fourth week, we focused on the instruction of general principles and process of mathematics education and NCTM standards for algebra in grade1-2 and 3-5 for elementary levels. Later we focused on integrating algebraic thinking through activities and various forms of algebraic thinking and especially functional thinking. After fourth week, teacher began to be familiar with examples and activities that foster algebraic thinking. We have discussed about activities and have specified that which activity related to which aspect and form of algebraic thinking and try to choose all activities that explicitly foster functional thinking. Teachers had a set of example and activities relation to functional thinking and they have sort activities in categories of functional thinking. Gradually they start to gathering activities from various sources.

 First instrument, Soc is a self-reporting instrument through a questionnaire (Fig. 1) that allows users to rank their perceptions of their concerns across seven categories according to three dimensions: self, task, and impact. The "self" dimension, with three stages (awareness, informational, and personal), reflects personal concerns. The "task" dimension refers to management concerns such as: time, both for planning and, implementation; logistics, in terms of organization and delivery of the innovation; and content coverage, with regard to program objectives. The "impact" dimension consists of three stages, the effect of the innovation on the students, efforts to collaborate with others in its use, and revision to effect greater change (Tunk & Weller, 2009).

 Results:

 We were identified a questionand collecting data using the instrument of CBAM (Soc). In addition the informal evaluations, data generated from Soc instrument was used for examining the question of study.

 Question:

 Concerns’ stage of teachers has measured using Soc questionnaire, and classroom observations during six months to response the first Question. First question of the study was: How did implementation of professional development program impact teachers’ concerns? The results of this measurement were shown in figure 2 (table and graph). Figure 2 illustrates changes in concern stages (vertical axis) across time (horizontal axis) and the individual results for each teacher denoted by Ti (i = 1,2,…15). We measured levels of concern of teachers in the end of each month. Figure 3 show the plenty of teachers in two months, in the middle of program (April) and in the end of term (July).
In the beginning of term, teachers resist opposite the program and they were not hopeful about significance of the program. But after one month they were interested to follow program. They began to struggle to familiar with functional thinking. In April ten teachers (T1, T2, T5, T6, T8, T9, T11, T12, T13, T14) progress till stage 2 (personal). Measurements of July showed more progress. Numbers of them improved till stage 4, 5 and 6. We recognize three types of teachers: first group (A) progressed till stage 3 (Management) they were T7, T10, T13, T14, T15, second group (B) progressed till stage 4 and 5 (Consequence, collaboration), they were T1, T2, T3, T5, T8, T11, T12, and third group (C) progressed till stage 6, they were T4, T6, and T9. As we mentioned in the beginning of the term all the teachers stated that this type of the algebra is not like what they know as algebra. Once we start to identify the concept of "function", they were worried and we recognized what we call "Mathematics anxiety".

**Fig. 2:** Survey of concern in 6 month.

**Fig. 3:** Frequency of teachers in survey of concern in two month.
Conclusion:
A significant ability that we tried to develop and progress in teachers was “ability of designing activity”. We see autonomy in task development as a key and critical component in development of teacher. Certainly resources that we introduced and used in the project were limited. Activity designing, not only led to developing resources’ field but also, was an indicator of their mastery on subjects and processes defined as functional thinking. Increasingly, teachers became skilled in finding, adopting, and designing of the resources that led to developing algebraic reasoning.

Teachers come to construct links between the visual pattern and tables of values and to eventually integrate the representational systems, flexibility moving between them, that is, abstract the mathematical concept (function) and that is the sequential way of representation for supporting learning.

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