Curriculum Focal Points: A framework for pre-k-8 teachers' professional development

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Abstract: Trends in International Mathematics and Science Study raised the concern that the United States (US) mathematics teachers place less emphasis on topics and teach a variety of content strands (Goldsmith, Mark & Kantrov, 2000; Kerachsky, 2008). The overall pattern in the US mathematics classrooms today is that primary and upper elementary teachers cover numerous topics before students achieve mastery (Cogan & Schmidt, 1999; National Center for Education Statistics, 1997). To solve this problem, US teachers need to find ways to focus fewer curriculum and study topics with a more in-depth agenda. Curriculum Focal Points for pre-kindergarten through grade 8 mathematics: a quest for coherence (National Council of Teachers of Mathematics, 2006) provides a strong framework that may assist teachers in creating a more coherent and focused mathematics program for students. In this article, the authors discuss example lessons that were implemented and observed in pre-kindergarten, fourth grade and sixth grade classrooms during a year-long professional development program. The overarching goal of this program was to provide appropriate instruction for teachers to organize mathematics standards-based curriculum in geometry, algebra and measurement, using a curriculum that emphasizes a strong conceptual framework. As an outcome of this exploratory research agenda, the authors' intentions were to circulate "best practices" and encourage international connections and discussion when using Curriculum Focal Points (CFP) in global classrooms.

Key words: curriculum; professional development; mathematics teaching and learning

1. Introduction

> We do not have time to teach math topics in- depth because of the demands of PSSA (Pennsylvania System of State Assessment) and NCLB (No Child Left Behind) agendas. (Fifth grade teacher)
>
> We do not have time to teach geometry because it is in the back of the textbook and often we don't get to the chapter. (Second grade teacher)
>
> We need to focus on teaching what will be on the PSSA test. (Fourth grade teacher)
>
> We cannot make connections from grade to grade because we do not know what each teacher is doing in math class. (Seventh grade teacher)

These are examples of teachers' opinions that are heard, not only in the professional development program in northeastern Pennsylvania, the United States (US), but also in classrooms across the nation. The Third International Mathematics and Science Study (TIMSS, 1996) raised the concern that the US mathematics teachers

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place less emphasis on topics and teach a variety of content strands. What seems to be the overall pattern in the US mathematics classrooms is that primary and upper elementary teachers cover numerous topics before students achieve mastery of a topic (National Center for Education Statistics, 1997, 2000). One reason for this instructional practice is that United States textbooks have been reviewed as being too broad based on content topics, than other countries that were involved in TIMSS research (Schmidt, McKnight & Raizen, 1997). In particular, TIMSS showed that 4th grade mathematics textbooks averaged 530 pages—three times more pages than other countries (Valverde & Schmidt, 1997). What this means is that the greater length of US textbooks encourages a teacher to cover more topics rather than focus on content areas in a more in-depth and problem-based manner.

To solve this problem, the US teachers should explore ways to focus fewer curriculum and study topics with a more in-depth agenda. Curriculum Focal Points for Pre-kindergarten through Grade 8 Mathematics: A Quest for Coherence (CFP) (National Council of Teachers of Mathematics (NCTM, 2006) provides a strong framework that may assist teachers in creating a more focused mathematics program for students that emphasize important concepts while integrating skills and procedures.

In this article, the authors discuss example lessons that were implemented and observed in pre-kindergarten, fourth grade and sixth grade classrooms during a year-long professional development program. The overarching goal of this program was to provide appropriate instruction for teachers to organize mathematics standards-based curriculum in geometry, algebra and measurement, in a coherent, focused curriculum. The authors, professors at a university, created a partnership with a local school district to consider an in-depth approach to teaching mathematics based on the integration of CFP. University professors were involved in the instruction and year-long follow-up coaching observations. Ethnographic methodology was used to assist educators in understanding the learning environment. Qualitative research was preferred because the program generated understanding, description and discovery about a field-based program. The professors, participant observers, collected data through a triangulation of methods which included teacher journals, professor (observer) journals, and field notes from class observations. Data gathering and data analysis were completed ongoingly throughout the study. All data was analyzed and collected. This article represents a snapshot of year-long research events.

To focus the teaching of mathematics in a more focused and in-depth manner, teachers in the program were encouraged to emphasize a content strand and make connections identified for each grade level, pre-kindergarten through 8. This was done by having authors and teachers create conversations around effective lessons. Classroom teachers agreed that this agenda was important. An eighth grade teacher in this year-long professional development program wrote the following journal entry:

> It seems as if there is so much information and so little time to complete all of it. Everything is so valuable but seems rushed. Another goal for the new school year is to try new things (learned from this professional development program). My only concern is time management. How to implement all of this new stuff, cover the old stuff and do PSSA (Pennsylvania System of State Assessment) stuff.

2. Why do we need Curriculum Focal Points?

The CFP provides three focal points (areas of emphasis) and three connections for each grade with continued integration of the process standards of problem solving, reasoning, communication and making connections. The National Education Association (NEA) (2006) presents a good summary of this new framework by stating:

> The focal points are intended as a first step toward a national discussion on how to bring consistency and coherence

> to the mathematics curricula used in the United States. At each grade level, pre-kindergarten through grade 8, the Curriculum Focal Points identify three topics, described as "cohesive clusters of related knowledge, skills and concepts", which form the necessary foundation for understanding concepts in higher-level mathematics.

Teachers often complain that the National Council of Teachers of Mathematics standards (2000) are too broad and that the state standards have too many topics. In the state and national standards, no content area or process strand is emphasized over another. CFP is easy to follow because this framework places emphasis on specific content strands and allows teachers to focus on very specific mathematics ideas. An eighth grade teacher commented on the CFP by saying: "These focal points make planning mathematics curriculum much easier. It is a guide to very specific ideas that students need to know on all grade levels".

Reys, Lindquist, Lambdin and Smith (2007) point out that the spiral approach, which is modelled in CFP, has profound implications for the teaching and learning process. Besides knowing what students have learned in previous grades, teachers must also understand what their students need to know next month and the following year. For example, fourth grade teachers must know what students learned in pre-kindergarten through third grade and understand what fourth graders should know. This broad perspective assist most teachers in finding gaps in their students' mathematics understandings, and with this information, teachers can effectively teach students what they need to know. A spiral curriculum (rather than reviewing topics grade by grade with repetition of skills) revisits topics with greater depth. Unfortunately, TIMSS (1996) reported that the US classrooms reflect more review of content topics from each grade level than do mathematics programs in other countries, such as Germany and Japan. The CFP provides a framework to encourage classroom teachers to consider an in-depth approach and problem-based learning.

Goldsmith, Mark and Kantrov (2000) stated that it is important to keep cross-grade articulation ideas in mind when making appropriate choices for standards-based curriculum on each grade level. This process gives consistency in the offerings of content understandings, concepts and process skills. The outcome of this type of cross-grade articulation is that education systems maximize the coherence of students' mathematics education experiences from pre-kindergarten through high school.

3. CFP advances collaborative discussions during professional development

How can CFP be used to improve the study of mathematics topics? The authors of this article designed a year-long professional development program for teachers. The project components took place over a one-year cycle of development which included a one-week summer academy, two day-long follow-up staff development sessions, classroom visits by university professors, and two evening institutes. During these sessions, participants were instructed in lesson design and assessment which were then observed during the classroom visits. A component of each session included reflective conversations on the previous lesson, and professors modelled the reflective journaling that was expected during classroom visitation. Journal data helped educators think about how teachers can focus school mathematics to assist students in knowing what matters and to understand mathematics in deep ways. The conversations began with an integration of the Principles and Standards for School Mathematics (NCTM, 2000) and Academic Standards for Mathematics (Pennsylvania Department of Education, 2007) in agendas. However, since September, 2006, CFP advanced collaborative discussions to more in-depth conversations around specific topics. Introduction lesson ideas were not only identified, but lesson concepts were also expanded. The rationale for this framework was to allow teachers to apply a more coherent and focused

approach to teach mathematics and to assist teachers in covering topics that connect with other topics in later grades.

3.1 Lessons

The following three classroom lessons are examples of how pre-kindergarten, fourth grade and sixth grade teachers implemented geometry lessons that were integrated with algebra and measurement ideas. Mathematical processes of problem solving, reasoning, communication, connections and representations were also addressed. For purposes of discussion, a section describing strategies for improvement follows each lesson and offers ideas on how the classroom teacher could enhance classroom teaching with a more coherent and focused study of concepts during grade-level lessons and in anticipation of cross-grade connections.

3.2 Classroom lesson 1

Lesson 1 took place in a pre-kindergarten classroom and the topic for the lesson was titled Exploring Geometric Shapes and Relationships.

The teacher placed a path of footprints in the shape and sequence of a rectangle-triangle-circle-square which students could step on as they listened to the song *FootPrints* (Patrick, 1983). Then, the teacher unveiled a four-headed monster—each head had eyes, nose and mouth as one of the shapes listed above. A second activity required students to feed a four-headed monster by matching an attribute block with the shape of the monster's head. The children were then given various geometric shapes made from construction paper and they created their own monster. The pre-kindergarten teacher's reflective journal entry was as follows:

> I really feel that my lesson went extremely well. The children really liked the song of *Footprints*: The children followed the footprints and then sat on the carpet and had to say what made the prints. By listening to the song they found out it was a four footed monster with different polygon footprints. They had to recite the pattern rectangle-triangle-circle-square several times. The four headed monster revealed and the children had to describe the shapes of each monster and then they were allowed to feed them appropriate shaped food.

From the teacher's reflective journal, it is obvious that the concepts that were covered in this lesson were fairly limited. The teacher emphasized the identification of shapes and also implied that the term polygon included the circle. During the professional development conversations, a discussion occurred about how this teacher might continue to build a foundation for concentrated studies in geometry, measurement and algebra.

The observer stated that, since the students seem to have recognition of the four basic shapes, this lesson could be extended by having students find rectangles, triangles, circles and squares in the classroom. It was recommended that the geometric shapes be used to form patterns and incorporate pattern recognition with shape recognition. This teacher should consider the CFP for pre-kindergarten mathematics. The CFP emphasizes that young children should identify shapes, describe spatial relationships, and concentrate on identifying measurable attributes by comparing objects using these attributes.

3.3 Strategies to integrate Curriculum Focal Points

Integrating the focal points and connections allows teachers to expand students' mathematics knowledge by providing opportunities to create real-world objects made of specific shapes; compare and use appropriate attributes to measure the size of shapes; make direct comparisons of shapes to identify large, medium and small objects; and use these shapes to follow a-b patterns and a-b-a patterns. The point to be made is that the properties and relationships of shapes should be emphasized. As stated in the pre-kindergarten CFP and connections to the focal points, the following objectives are followed in lessons:

(1) Construct pictures and designs by combining two- and three- dimensional shapes;

(2) Identify measurable attributes such as length and weight and solve problems by making direct comparisons of objects on the basis of those attributes;

(3) Explore the foundation of data analysis by using objects' attributes that they have identified in relation to geometry and measurement (e.g., size, quantity, and orientation, number of sides or vertices, color) for various purposes, such as describing, sorting, or comparing.

NCTM (2000, p. 41) standards state, "Geometry is more than definitions; it is about describing relationships and reasoning". Bruni and Seidenstein (1990) stated that young children's first experiences should be to understand the world around them by observing spatial and geometric shapes. This lesson could be further extended to the next grade level by incorporating three-dimensional shapes into the monster program. CFP (NCTM, 2006) states the following:

> Children develop spatial reasoning by working from two perspectives on space as they examine the shapes of objects and inspect their relative positions. They build pictures and designs by combining two- and three- dimensional shapes, and they solve such problems as deciding which piece will fit into a space in a puzzle (p.11).

Since all of the monsters were three-dimensional, the students have the opportunity to be introduced to spheres, cubes, and cylinders. The students should explore and discover that three-dimensional shapes often share attributes with some of the corresponding two-dimensional shapes (e.g., cubes are made up of squares, cylinders have circles for bases). Children should practice putting two-dimensional shapes together to form new shapes. Naming shapes, even at an early age, depends on understanding a combination of geometric relationships (Clements & Sarama, 2000). Understanding the relationships of shapes are the foundation for understanding the concepts of big ideas of elementary school geometry (Lerch, 1981; Thornton, Tucker, Dossey & Bazik, 1983) that help young children to classify, name, and use the shapes. The big ideas are straightness, congruence, similarity, parallelism, perpendicularity, symmetry, and concepts that are explored and developed in elementary grades and beyond.

3.4 Classroom lesson 2

Lesson 2 focused on the fourth grade classroom and the topic was titled Polygons.

The teacher used the book *The Greedy Triangle* (Burns, 1994) to introduce students to polygons with different numbers of sides. Students were asked to predict what shape would come next and then follow with a new construction of a polygon on a geoboard. They also identified any of the same shapes that they observed in the classroom environment. The fourth graders worked in small collaborative groups. The teacher named a polygon and each group worked with KNEX, a toy construction system, to construct the polygon. The students discussed the properties of the polygon. They concluded the experience by spreading shaving cream on each student's desk and each fourth grader practiced drawing polygons.

The professional development conversations targeted the following question: How may this teacher improve instruction in geometry and measurement for her fourth graders by considering a more clear and concentrated depth of study? The fourth grade teacher's reflective journal entry on this lesson was reviewed in order to gain an understanding of the lesson process. The teacher wrote the following:

> I've been using many of the manipulatives to supplement my geometry unit from ideas and materials we received during the summer professional development workshops. Strategies from the workshops to develop concepts and to think about outlining a more in-depth study of the content strand of geometry are very helpful.

The teacher used many kinds of materials for the lesson but explored the topic with little depth. The observer

reflected on the lesson by writing the following journal entry:

> It was good to see that the teacher introduced the definition of a polygon using the integration of literature. Fourth graders estimated the different polygons by adding another line segment from which it was constructed. The students followed a problem-solving approach, applying information to construct new polygons on a geoboard. Although the students discussed and recognized the properties of each polygon individually, they did not seem to completely understand the composition of the polygons they were forming by simply adding another side and another angle.

Collaborative conversations between teachers and professors revealed that the teachers had the intention of allowing students to construct their own polygons during a problem-based lesson generated from their own interpretations of the story. The weakness in the lesson was the lack of specific concepts. The observer touched on this issue by pointing out that the students did not understand the composition of polygons even though students were adding line segments to form new ones. The teacher was reminded that the CFP for fourth grade mathematics focuses on developing an understanding of area and determining the areas of two-dimensional shapes.

3.5 Strategies to integrate Curriculum Focal Points

When CFP is applied to this lesson, the students should have created their own definition of a polygon. Students' ideas should include that a polygon must have three sides and the endpoints at which the segments are joined are called vertices. Based on the big idea of straightness, children should realize that the line segments or edges are straight. At this grade level, students should identify that two lines are parallel and the lines do not intersect no matter how far they are extended. During the elementary grades, students should understand the congruence of simple figures such as line segments and angles. It should be pointed out that, when two figures have the same size and the same shape, the figures are congruent. The students should make connections by building on their earlier work with congruence.

In general, students should realize that a polygon with n sides will have n vertices. A regular polygon should be explored by having students construct polygons with all sides that have the same length and all angles have the same measure. Many of the polygons that are constructed may be classified in terms of their angles, side lengths, and other properties. Also, fourth graders should be encouraged to decompose shapes. The teacher could extend this lesson to have students form new polygons by combining triangles to form parallelograms, rhombus, pentagons, etc. The relationship between specific types of triangles (isosceles, right, equilateral) and the newly formed polygons should be investigated and described by the students. This exercise in forming new polygons should then be extended to incorporate an understanding of the concept of area of a polygon. Students should be able to approximate the area of the polygon they form by using a unit square. Students should also be able to identify how many lines of symmetry a polygon has. In short, the teacher should focus on an in-depth study to develop concepts students need to know in later years.

3.6 Classroom lesson 3

Lesson 3 focused on the sixth grade. The topic of the lesson was titled *Three-dimensional shapes and analyzing the properties, including volume and surface area.*

Students were given two sheets of 8 1/2×11 papers and were asked to form two cylinders with different bases and heights. Students taped together the 8 1/2 inch side of the first sheet of paper as the height and then the 11 inch side of the other sheet as the height. Then, students estimated which had a greater volume. Students tested the hypothesis by filling the taller cylinder with cereal, and they poured the cereal into the second cylinder to see if it held the same amount. Students found the actual volume of each cylinder by using the formula ($v=\pi r^2 h$) and

formed a conclusion.

The professional development conversations targeted the question "How may this sixth grade teacher improve instruction by considering a more clear and concentrated depth of study of concepts". The sixth grade teacher's reflective journal entry included a description of the task as follows:

> Today your groups will explore the following problem: when you take the same size paper and fold it two different ways to make two different cylinders, do you get the same volume? All groups should fill cylinder B with cereal then empty cylinder B into cylinder A. Find the volume of each cylinder and decide if volumes are different, even though you begin with the same size paper.

The explanation of the task is satisfactory. However, does the teacher guide the sixth graders into a more in-depth learning experience and consider cross-grade connections? The observer stated that this activity could have been extended to have the students form five different three-dimensional figures (a rectangular prism, triangular prism, cylinders, etc.) from the same 8 1/2×11 sheet of paper, and compare both lateral area and volume of each solid. Students should have been able to analyze their results and draw a conclusion of the area of all prisms and cylinders (area of base×height). The teacher was reminded that the CFP for sixth grade mathematics focuses on writing, interpreting, and using mathematical expressions and equations.

3.7 Strategies to integrate Curriculum Focal Points

When using CFP and connections in this lesson and beyond, sixth graders should review that capacity is the volume that can be held in a container and that the definition for volume is the number of cubic units needed to fill a solid figure. Most students are sure the volume of both cylinders is the same. A student wrote in his journal, "It was a fun experience for me. I was surprised to find out that the volumes were different. It made me understand more about volume. I thought it was going to be the same volume but the shorter and wider one was bigger. That was what surprised me". This activity allowed them to extend their perception of special relationships to the world around them. In previous grades, children have initial activities that allow them to identify that cubic inches are used to determine volumes. Often the phrase cubic inch is used through the fifth grade. In the sixth grade and beyond, the abbreviated notation in is introduced (Burris, 2005).

Children at this age should make connections by writing and interpreting math expressions and equations, and think about the following questions: What is the name of the form that is created with paper? What is the name of the figure that is the base? Is the base a polygon? What is the formula for the area of this base? What is the volume formula for the figure? What is volume? This lesson could be further extended by having students investigate the relationships between area and volume of two similar figures as the lengths of two corresponding sides are increased proportionally.

4. Implications for future professional development for teachers

As we began integrating the CFP into our conversations and reflection process, we realized that the focal points give a clear understanding as to how to extend mathematics concepts with a deeper approach to learning with a cross-grade focus. Effective instructional practices are created by a teacher's in-depth background in mathematics—background knowledge that is gained through ongoing professional development. It would be helpful if teams of teachers across grade levels collaborate and plan units of study while using the CFP as guides. It is important that all teachers are familiar with focal points of previous and future grade levels. Clearly, teachers need a deep understanding of the mathematical content and skills that they are required to teach. As an outcome,

the set of curriculum focal points are used as a guide for all teachers to teach grade level content that can build connected and integrated mathematical understanding for students at each level.

5. International connections

This paper presented at the *International Technology, Education and Development Conference* in Valencia, Spain on the 9th of March, 2009. Present at this conference session were professors that represented a variety of countries (i.e. Finland, China, Romania, England, and the United States). The audience was asked to give feedback to how this mathematics education reform agenda relates to their own teaching and learning setting and the effectiveness of the various approaches mentioned in this paper. From comments of the audience it was apparent that there were great differences between the instructional styles in other countries to that of US school reform agendas. It seems in most countries, with the exception of England, Finland and the United States, popular pedagogy in most countries use a model where concepts are explained by the teachers in a transmission mode. From some members of the audience, a more hands-on approach to teaching methodology was viewed as children playing, rather than learning concepts.

The United States mathematics school reform agendas are encouraging teachers to move away from conducting lessons that ask students to memorize terms and practice procedures. This study looked at applying what school reform issues encourage—real-to-life tasks, emphasizing problem-based learning through a strong conceptual framework.

6. Conclusion

In this article, lessons for three different grade levels were discussed. An interesting element surfaced as we reflected on the classroom lessons—we found exactly what the research is telling us. Lessons have many limitations to the mathematics teaching and learning process. In the pre-kindergarten class, although the teacher met the focal point of having students identify measurable attributes of geometric figures, she failed to make the connection to algebra by recognizing sequential patterns. In our second classroom lesson on polygons, the teacher used many kinds of materials, but was unsuccessful because her students did not understand the composition of the polygons even though they could add line segments to form new ones. In the sixth grade classroom lesson on analyzing and investigating three-dimensional shapes, the teacher clearly presented a task, but the lesson could have been extended further. The observer stated that the task could have included more three-dimensional figures and could have also compared both lateral area and volume of each solid.

Integrating CFP into the curriculum assisted us in considering the following elements: (1) a more concentrated mathematics program focusing on fewer topics; (2) a connection to cross-curricula grades; and (3) a desire to alleviate the teaching of repetition of skills. The underlying goal is to understand the knowledge-base of students and to build on that knowledge. As an outcome of trying to accommodate curricula concerns, the CFP provided a strong framework to help overcome such problems.

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