Concept Mapping: Connecting Educators
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PROFESSIONAL LEARNING OF MIDDLE SCHOOL AND PRESCHOOL TEACHERS USING CONCEPT MAPPING

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Abstract. The purpose of this paper is to describe the professional learning of teachers as they acquire the knowledge and skill to use concept mapping for instructional planning, as an instructional strategy, and to assess children's conceptual knowledge. The professional learning involved middle school mathematics and science teachers as they used concept mapping to develop a summer camp program and preschool teachers as they designed and implemented the *Young Florida Naturalists* and *Healthy Habits through Literacy* projects which embedded concept mapping in the lessons. We found that it is important to immediately use concept mapping in real-world, concrete ways and to provide feedback during the process. In our work with the preschool teachers, we accomplished this by using the professional development workshops to develop specific lessons/curricula the teachers would subsequently use in their daily practice. This is in contrast to providing concept mapping skills at professional learning workshops and then assuming teachers, on their own, would overlay concept mapping strategies in their practice. Additionally, we found on-site scaffolding and organizational support were critical to implementation of the preschool projects.

1 Introduction

Over the past several years, advancements in cognitive and learning science have begun to inform both learning and instructional design (Carver & Klahr 2001). Thus, research findings are used to both inform teachers' professional learning and to structure students' learning experiences. Novak and Gowin (1984) suggested that learning is an active process that involves acquiring, creating, and using knowledge. Furthermore, learning takes place on a continuum ranging from rote to meaningful. For learning to be meaningful, three conditions must be present: the learner must possess some prior relevant knowledge to which the new information can connect, the new information must contain significant concepts and propositions, and the learner must consciously and deliberately choose to relate in a meaningful way the new knowledge to the existing knowledge. Through this process, learners build knowledge by making a growing network of connections. The purpose of this paper is to describe the professional learning of teachers as they learn how to use concept mapping as a visual representation of the structure of their knowledge, as a process for building content knowledge, as a method to assist in designing curricula and lessons, and as a form of assessment.

1.1 Concept Mapping

In this paper we report on the professional learning of preschool teachers as they designed and implemented preschool curricula incorporating concept mapping and middle school teachers as they designed summer camps and implemented concept mapping in their everyday practice. Concept mapping has been widely used to assess the structure of learner's knowledge especially in science. However, concept mapping is used across many domains and across a considerable age span of learners. Novak and Cañas (2008) stated that concept maps are graphical representations of knowledge. Concept maps visually depict separate but related concepts by showing the relationship between the concepts with a line, or directional arrow. The words on the linking lines represent the relationship between the concepts. Two linked concepts are called a proposition, and propositions form meaningful statements when read. Concept maps generally represent concepts in a hierarchical fashion with the most general or overarching concepts at the top and subordinate concepts and examples towards the bottom. Concept maps can also have cross-links which connect concepts in different segments (branches, domains, or strings) of the map. Novak and Cañas contended that the two features of concept maps that indicate *leaps of creative thinking* are the hierarchical structure of the map and the use of cross-links.

1.2 Professional Development and Change Theory

In discussing the effectiveness of the professional learning of our teachers, we use Gusky's (2000) framework that links professional development to improved student learning. In developing the framework, Gusky recognized that student learning will not automatically follow professional development and that successful professional learning engages five levels which are hierarchical in nature with success at one level depending on success at the lower or preceding levels. The five levels as described by Gusky include the participants' reactions to the professional development, the participants' learning, the organizational support and change, the

participants' use of the new knowledge and skills, and the intended student learning. First, the participants must consider the professional learning experience time well spent. Positive reaction facilitates participant learning. Participants' learning represents the extent to which participants increase their knowledge, acquire new skills, and possibly change their attitudes/beliefs. If participants are to apply what they have learned with fidelity, they first must learn what is expected. Implementation of the professional learning requires that individual change occurs and, in addition, that organizational support for the learning occurs. Organizational support can include but is not limited to providing the resources and time necessary to implement the new learning and collegial support for and recognition of the change. The participants' use of the new learning involves recognition that change is a dynamic process rather than static event. The personal aspects of the teachers' change process typically reflect levels of concern about their ability to implement the required change (George, Hall, & Stiegelbauer, 2006). In all of our professional learning activities, the desired outcome was improved student learning and the teachers functioned as designers, implementers, and/or evaluators of students' learning experiences.

Scaffolding can be embedded in professional learning to increase its effectiveness and facilitate the change process (Harris, 1991; Moll, 1990; & Vygotsky, 1978). Scaffolding can be involved in the participants' learning, the organizational support and change, and the participants' use of the new knowledge and skills by establishing shared goals, asking probing questions to identify current levels of understanding, providing support that is tailored to the identified needs, mediating organizational support, and providing regular feedback. Thus, scaffolding helps teachers move through the change process both in terms of their stages of concern regarding the implementation, their developing expertise using concept mapping, and implementing concept mapping strategies with their students.

2 Professional Learning and Concept Mapping at the Middle School Level

Our first attempt at using concept mapping in conjunction with professional learning involved middle school teachers serving low-income neighborhoods in two counties, one urban and one rural. The participants were middle school mathematics and science teachers primarily participating in the professional development to prepare curriculum materials for mathematics and science summer camps. The focal content of the workshops was mathematics, specifically Algebra I. Professional development activities included four, all-day Saturday workshops designed for the teachers to learn to use IHMC CmapTools™ (Institute for Human and Machine Cognition) and to use concept mapping for lesson planning, instruction, and assessment of student progress in mathematics. Additionally, during the late spring and early summer, teachers worked to plan activities for the summer camp held at their school. The purpose of summer camp was to motivate the selected students toward mathematics, science, and technology (MST) careers and toward enrollment in college preparatory mathematics and science courses. The development and delivery of activities for summer camp provided further concept mapping experiences for the middle school teachers.

The professional development workshops progressed from a general introduction of concept mapping, to making concept maps from a *parking lot* of concepts, making concept maps of provided mathematical concept, and concept mapping a textbook unit. Professional development time was also allocated for teachers to examine an existing set of *expert* concept maps developed by university faculty and high school mathematics teachers. The amount of time spent on developing the teachers' mathematical content precluded researchers from providing a thorough introduction to the use of concept maps for student assessment. It was hoped by the research team that the teachers involved in the professional learning would continue to use CMap Tools™ as an instructional planning tool, to strengthen their own understanding of key mathematical concepts and the connections between them, and to assess students' knowledge. Subsequent follow-up discussions with the teachers and school partners showed that this was not the case.

2.1 Lessons Learned

1. Conducting professional learning for using concept mapping with all of the original design components (concept maps for planning, instructional delivery and, assessment) was too much information to introduce through one professional learning experience even though it was spread over several weeks. There was no guided practice between the professional development workshops. Subsequent workshops demonstrated that *incremental learning* followed up by supported practice was necessary to improve teachers' knowledge and use of concept mapping.

2. In the initial concept mapping workshop experience, teachers worked individually. Collaboration could have provided suggestions for improvement and feedback. We incorporated *team learning* in subsequent professional learning.
3. Stand-alone professional development/training is necessary but not sufficient to produce desired change. Ongoing support is necessary if teachers are to adopt new methods and change their practice.

3 Professional Learning and Concept Mapping at the Preschool Level

The preschool curricula were designed with concept mapping embedded in the lessons and concept mapping was used in the planning stages. Researchers used concept mapping combined with *Understanding by Design* (Wiggins & McTighe, 2005) to form an intentional and explicit instructional planning framework. Wiggins and McTighe's backward design begins by identifying specific understandings and skills desired for learners and then specifies learner behaviors that provide evidence of the outcomes—all prior to the development of the learning activities and/or experiences. Concept mapping was used in the preschool curricula development process to help teachers focus on the essential content addressed, identify important concepts related to the content, and make explicit the connections among the important concepts. Developing and sharing concept maps during the professional learning experiences clarified the teachers' thinking (including misconceptions) about the content and made the instructional design more coherent. Finally, teachers used concept maps to reflect upon their learning, to see how concept mapping could help children increase their conceptual understanding, and how the children's concept maps could be used to assess the extent to which the complexity of their knowledge increased over the implementation of the lessons.

3.1 The Young Florida Naturalists Curriculum

The *Young Florida Naturalist* curriculum was developed and implemented for use in three preschool classes in an urban professional learning demonstration preschool center that primarily enrolls low-SES, African American children. This project provided the opportunity to incorporate and test the lessons learned from the middle school teachers' professional development. The *Young Florida Naturalists* curriculum focused on increasing the background knowledge and concept development of 3-year-old preschool and prekindergarten children. Learning experiences involved plants and their role in the environment. Building background knowledge was emphasized as children engaged in concrete experiences, and vocabulary development was emphasized through read-aloud activities. Concept mapping was used to document the hierarchical relationships described by the children before, during, and after the learning experiences. The curriculum was implemented in two classes of prekindergarteners and one class of 3-year-old preschoolers. Moreover, one or two of the project researchers were on site most of the time during the project's implementation. During implementation of the concept mapping preschool curricula, the research team provided initial instruction, modeled expected behaviors, and provided support as teachers developed their own concept maps as well as when teachers began using concept mapping with their children.

After the initial concept mapping introduction and demonstration, professional learning at the preschool center continued with multiple opportunities for teachers to practice building concept maps as a team as they planned the instructional unit. It was through this process that teachers began to develop an understanding of the hierarchal nature of concept maps and were able to make their own thinking explicit. The initial pre-instructional concept map developed by the teachers is shown in Figure 1. From this map, teachers identified some essential questions critical to the lessons developed using the backward design process.

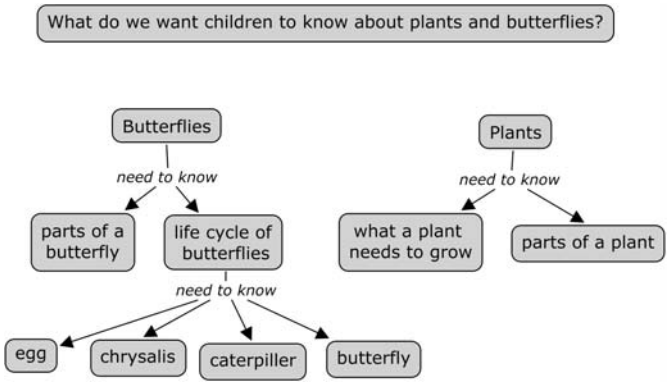

Figure 1. What do we want children to know about plants and butterflies?

After the development of the curriculum concept map, project researchers modeled for the teachers the process of creating concept maps with preschool children. The first concept map developed prior to instruction was constructed by soliciting from the children their current understanding about plants and butterflies. After assessing the children's prior knowledge, teachers began implementing the lessons. The teachers created a team concept map at the conclusion of the 8-week unit. The resulting concept map, shown in Figure 2, indicates an increase in complexity, cross-links and levels in the represented knowledge structure. The *Young Florida Naturalist* project demonstrated that professional learning can help teachers make connections among concepts and can substantiate for them the value of concept mapping in making children's thinking explicit.

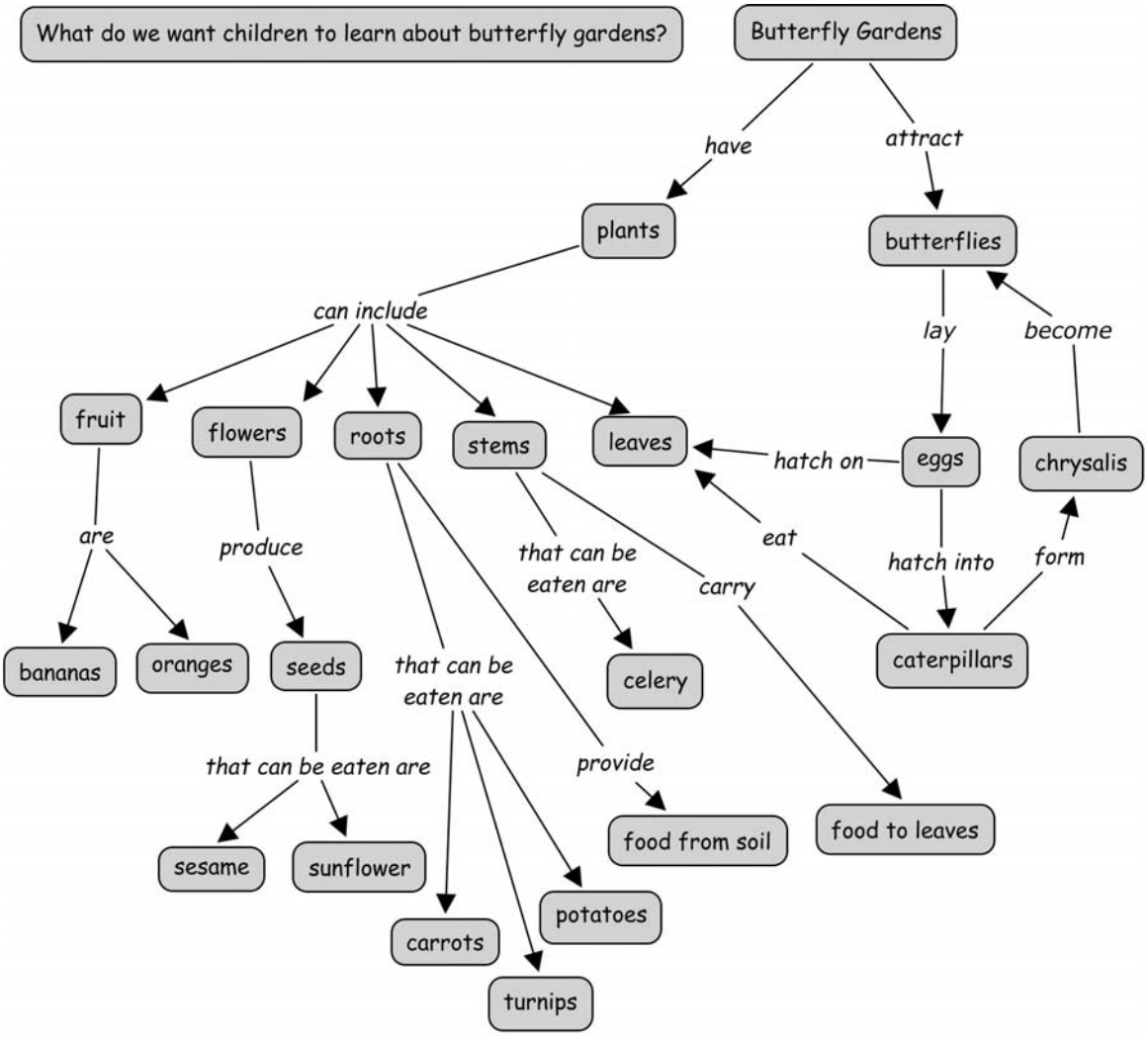

Figure 2. What do we want children to know about butterfly gardens?

3.2 The Healthy Habits through Literacy

The *Healthy Habits through Literacy* curriculum provided a third opportunity to investigate the use of concept mapping as an instructional and learning tool, the second opportunity involving teachers of preschool children. *Healthy Habits through Literacy* was designed to combat the rise in childhood obesity by building children's knowledge and concept development of health-related topics. The curriculum supports the goal of improving school readiness outcomes for preschool children by utilizing strategies that help young children develop thinking strategies. This project was implemented at same preschool enter as the *Young Florida Naturalists* project and the professional learning included one returning teacher and one returning teacher's assistant.

At the initial professional development session, the returning teacher and teachers' assistant shared testimonies concerning the positive effect concept mapping had on their personal understanding of the butterfly and plant concepts and the connections between them. The first professional development session also included

a video capturing preschool teachers and their children engaged in class concept mapping during implementation of the *Young Florida Naturalist* project. Using instructional materials gathered for the *Healthy Habits through Literacy* curriculum unit, teachers worked as a team to develop a concept map that would guide their teaching of the unit. The concept map is shown in see Figure 3.

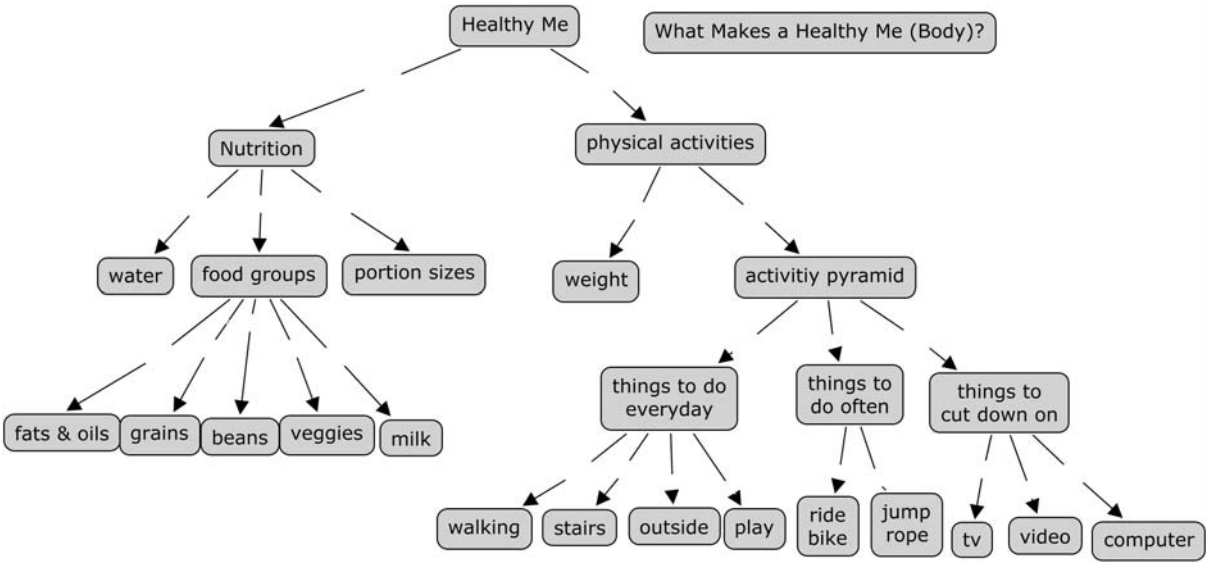

Figure 3. What makes a healthy me (body)?

Members of the research team are on site meeting with the teachers weekly to model the process of making concept maps with children and to help them modify the class concept map as their children's knowledge increases. The *Healthy Habits through Literacy* project will last for 12 weeks.

4 Discussion

The discussion of the effectiveness of the three professional learning experiences will use Gusky's (2000) five levels as a framework. The five levels are hierarchical in nature and include the participants' reactions to the professional development, the participants' learning, the organizational support and change, the participants' use of the new knowledge and skills, and the intended student learning.

Teaching staff involved in all three professional learning experiences expressed satisfaction with the workshops and thought that learning about concept mapping as a visual representation of knowledge was time well spent. The middle school mathematics and science teachers met on Saturdays in the library of an involved school. The preschool professional learning occurred at the center during the school day which, in our opinion, provides the optimal context for the professional learning.

Teaching staff involved in all three professional learning experiences gained knowledge about concept mapping. In working with the middle school teachers, we overestimated the extent of their content knowledge and thus we underestimated the time required to teach them to use concept mapping for planning, instruction, and assessment. Using the lessons learned from this experience, we more narrowly focused the preschool teachers' professional learning of concept mapping. The first preschool professional learning involved teachers who helped design and implement the *Young Florida Naturalists* project, an 8-week curriculum. In this instance, the teachers were totally immersed in the project in contrast to the middle school teachers who were asked to overlay concept mapping strategies on an existing state approved and county mandated mathematics curriculum. Additionally, the preschool teachers, working as a team with the university researchers, immediately used concept mapping to design the lessons in the *Young Florida Naturalists* curriculum. This immediate, guided use of concept mapping in a real-world situation helped the teachers realize the potential of visually representing knowledge. The second preschool experience, the *Healthy Habits through Literacy* project built upon the first. The presence of returning teaching staff allowed us to provide evidence of concept mapping success through testimonials and videos of teachers successfully using concept mapping with preschool children.

At the organizational support and change level in the hierarchical framework, the effectiveness of the professional learning of the middle school and preschool teachers diverges. At the preschool center, the organizational staff was supportive of the project and the staff's involvement. The research team included the teaching staff in designing curricula lessons and the administrative staff was always welcome. Artifacts of the implementation of *Young Florida Naturalists* and *Healthy Habits through Literacy* were highly visible throughout the preschool center. We found this level of professional development effectiveness more difficult at the middle schools than at the preschool center. The administrative bureaucracy of the public school system is very large having layers of officials who need to support change, thus gaining support is more difficult than at preschool centers which are not part of the public school system. At each middle school, the administrative staff verbalized complete support of the concept mapping project; however, they did not attend any professional learning workshops. Another simple example of conflicted support came at one middle school where the IT staff allowed installation of IHMC CmapTools on the schools' computers for the Saturday professional training but uninstalled the program before school resumed on Monday.

At the level of participants' use of the knowledge acquired through profession learning, the effectiveness of the professional learning of the preschool and middle school teachers also diverged. Whether or not the middle school teachers implemented what they learned about concept mapping in their practice is unknown. They used concept mapping to design the summer camp curriculum during professional learning workshops and used the lessons in summer camp. Learning from our experience with the middle school teachers, the university researchers were far more involved with the implementations of *Young Florida Naturalists* and *Healthy Habits through Literacy* preschool projects. Unlike the middle school teachers, the preschool teachers' professional learning was not limited to workshops, but scaffolding which offered individualized support was provided and was ongoing throughout the projects' implementations.

The impact of the professional learning on student achievement at the middle schools is unknown. The preschool children's concept maps show increased complexity in their knowledge structures of concepts related to plants. A goal of both preschool curricula is to improve the children's background knowledge. This extent to which concept mapping in preschool achieves this goal is unknown at this time.

5 Conclusions

Improving learning outcomes for all children, particularly for low-SES children, continues to be a high priority at the local, state, and national levels. Reform efforts at all educational levels, prekindergarten through twelfth grade, have raised expectations for student performance, and as a result, increased expectations for teacher performance. There is little debate over the importance teacher quality and quality teaching plays in improving student performance (Corcoran, 2007).

To meet rising expectations and increase instructional capacity, teachers must strengthen their content and pedagogical knowledge as well as increase their proficiency in using them with their students. Cohen and Ball (1999) defined instructional capacity as:

> The capacity to produce worthwhile and substantial learning and is a function of the interaction among three elements – teachers and students around educational materials—not the sole province of any single one, such as teachers' knowledge and skill or curriculum. (p 2-3)

One important strategy for increasing instructional capacity is engaging in ongoing teacher learning and professional development. Standards and features of effective professional development have been identified (Corcoran, 2007; Elmore, 2002; Roy, 2006). The professional learning model emerging from our work embodies many of those elements including a clear focus on improving student learning, engaging in active, content-based learning, job-embedded support, team learning—all nested in researcher/practitioner partnerships.

Because we know that change is a dynamic process rather than a static event, we are excited about the results from 2 years of professional learning at the preschool center. Several key features of the preschool teachers' professional development supported the successful implementation of the projects. It is important to immediately use concept mapping in real-world, concrete ways and to provide feedback during the process. This was accomplished in our work with the preschool teachers by including within the professional learning the development of specific lessons/curricula the teachers would subsequently use as part of their daily practice. This is in contrast to providing concept mapping skills at professional learning workshops and then assuming teachers, on their own, will overlay concept mapping strategies in their practice. The content-based middle

school teachers needed more support than we acknowledged as they transitioned from learning about concept mapping to using it in their practice. Thus, the on-site scaffolding and organizational support were critical to the successful implementation of the preschool projects.

We hope to build on the preschool success by implementing the curricula within one academic year—one in the fall and the other in the spring, thus increasing the children's exposure to concept mapping. However, because the *Young Florida Naturalists* and *Healthy Habits through Literacy* projects were implemented over 2 academic years, they provided an opportunity to longitudinally study the children who experienced concept mapping as 3-year-old preschoolers and then again as prekindergarteners. Preliminary results suggest the children benefited from 2 years of concept mapping experience. We would also like to extend the use of concept mapping to kindergarten teachers' practice thus providing children with three consecutive years of concept mapping experience. Expanding the children's concept mapping experience to kindergarten creates additional challenges. However, increasing the background knowledge of low-SES children is too important not to try to overcome the challenges.

6 Acknowledgements

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