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THE STUDY OF CONCEPT MAP IMPLEMENTATION FOR ENHANCING PROFESSIONAL KNOWLEDGE OF A HIGH SCHOOL MATHEMATICS TEACHER

Shian Leou National Kaohsiung Normal University, Taiwan
Janice C. Liu University of Northern Colorado, U.S.A..
Email: t1251@nknucc.nknu.edu.tw

Abstract. This paper presents a case study of an eight-year teaching experiences junior high school teacher conducting the concept map as a mathematical teaching and learning tool to enhance her professional knowledge. Data collection for the study included the subject's interviews, classroom observations, the subjects' teacher professional development community discussion sessions, teaching videotaping, and students' learning material analysis. The findings are as follows: The subject teacher's role has been changed from the deliverer into the communicator and distributor. Through the discussion and sharing session with the Mathematics Teacher Professional Development Community discussion session (MTPDC), the subject's mathematics teaching beliefs has been changed. The teacher gained the more self-confidence about her mathematics teaching also raising the instructor's teaching effectiveness.
Keywords: concept map, teacher's belief, and teacher's professional knowledge.

1 Introduction

Teachers are expected to change their practices towards particular goals, which are usually made quite explicit by the implementers. Researchers have adopted a range of approaches to teacher education, development and change. Grant, Hiebert and Wearne (1998) mention three successful approaches, in terms of "how to bring teachers into the reform process": discussion with teachers about their beliefs and practices (Simon & Schifter, 1991); cognitively guided instruction (Fennema, Carpenter & Carey, 1993); and working intensively with teachers (Heaton & Lambert, 1993).

Many educators (Bolte, 1999; Kinchin & Hay, 2000; Ritchie & Volkl, 2000; Tsai, Lin, & Yuan, 2001) suggests that learning can be enhanced if the learning involves interaction, student-centered, and engaging activities where learners construct their understanding rather than more traditional methods of teacher-centered, direct instruction. In order to make learning organized and meaningful, J. D. Novak of Cornell University first developed a teaching strategy known as concept maps in the early 1980's. It was derived from Ausubel's learning theory, which places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. Many researchers (Novak, 2002, 2004; Quinn, Mintzes, & Laws, 2004) showed that concept maps enhance learners' academic learning by promoting inquiry-based, meaningful learning environment. It allows the structure of knowledge to be represented in a way that shows knowledge as being composed of concepts and the relationships between them, arranged in a hierarchical structure. Since concept maps have tremendous contribution to learner's learning, it would be interesting to see possible effects on teaching, especially in teachers' beliefs, and teachers' professional knowledge.

2 Literature Review

Based on the work of Novak (1984), the concept maps has been used as an indication of the connectedness of knowledge in science education. Chains of relationship can be formed by series of concepts related graphical presentations. Concept maps have been "developed specifically to tap into a learner's cognitive structure and to externalize, for both the learner and the teacher to see, what the learner already knows". Educational applications of concept mapping were used in a variety of settings include their use as a learning/study strategy and as an assessment instrument (Bartels, 1995; Beyerbach, 1988; Mansfield & Happs, 1991; Novak, 1991). Angelo and Cross (1993) stated that concept maps "stimulate students to create, and allow faculty to assess, original intellectual products that result from a synthesis of the course content and the students' intelligence, judgment, knowledge, and skills" (p. 181). Concept maps have also been used successfully in an instructional setting to differentiate student misconceptions (Bartels, 1995; Bolte, 1999; Novak, 1984).

In 1987, Shulman defines seven types of knowledge for teaching: content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of the learner, knowledge of educational context, and knowledge of educational purposes.

Kennedy (1990) mentioned mathematics teachers should possess certain requirements: knowing what is the concept, how students learn, and how students approach mathematical knowledge. Geddis (1993a, 1993b) emphasis that the pedagogical content knowledge is focused on how to transform the content knowledge into pedagogical knowledge.

Lee (1994) concluded teacher's beliefs are an assessment of the interrelated perspectives of teaching which based on teacher's knowledge value, logic value, social value, experiences and emotional concept. It is formed by various viewpoints on the issues related to teaching. In general, teacher preparation is focused on leading teacher's teaching beliefs to the teacher professional development. Teaching is not just simple demonstration of knowledge or rote memorization. It is a process of activities based on subject knowledge and approachable learning goals for learners. These activities also need to be conducted under careful considerations of characteristics such as knowledge itself, learner, learning environment, and the consequence of learning (Cooney, 1994). For teacher who monitors his/her own teaching activities, if reflections involved, will teacher initiate self-suspicion and further changing his/her teaching beliefs is also a focus point of this study.

3 Methods

The participant of this study is a junior high school mathematics teacher with eight years of teaching experience and a graduate from a teacher's college in Taiwan. The Mathematics Teacher Professional Development Community (MTPDC) discussion session is a group of teachers who volunteer to attend in an educational teaching growth discussion sessions. The inquiry and reflection aspects are the main approaches of the MTPDC. The concept map strategy for assessing her students' concept learning was introduced in these sessions. During these sessions, the subject found that concept map strategy could not only enhance student's learning but also elevate teacher's instruction. Therefore, the subject decided to integrate the concept map strategy into her geometry class.

In order to understand the development of the subject, an interpretational analysis was used in this study. Data collection for this study included interviews of the subject, classroom observations, the subjects' teacher professional development community discussion sessions, video recording during teaching activities, and students' learning material. All above data collection techniques were conducted and completed within five months of time. Through various channels of data collection, researchers were not only able to properly triangulate research results, but also increasing its reliability and validity of this research.

By following the principles of case study design, the data for this study consisted of in-depth interviews and classroom observations. Researchers in this qualitative study were the primary instrument of data collection and analysis. Analysis of collected data was an on-going task while researchers participated in previously described data collection process. Interviews, field notes, and observations were transcribed into text for identifying categories for data analysis and triangulation purposes.

4 Findings

4.1 Subject teacher's beliefs

"Teachers themselves need experiences in doing mathematics--in exploring, guessing, testing, sting, estimating, arguing, and proving ... they should learn mathematics in a manner that encourages active engagement with mathematical ideas. " (MSEB & NRC, 1989, p.65) From the literature review we found most of educators agree that teacher's beliefs have impact in teacher's teaching. Because of the complications in teaching process, teacher's content knowledge and external factors, teacher's teaching beliefs and his/her teaching performances would not be consistent. Base on the consideration of the discordant, the data analysis in this study was focused primarily on the subject's interviews and classroom observations.

The subject's mathematics teaching beliefs were to be a hard working person and a responsible teacher for her classes. She also believed that an easygoing learning environment would help students like mathematics. On the students' mathematics learning beliefs, subject believed that if students could acquire more time to practice, mathematics concepts would be reinforced. From the interview, she said, "I used to believe that more materials I teach, the better students will learn. It's like stuffed concepts and knowledge in to them. I tired very hard to use every minute to deliver materials. I don't care about their feedback, I don't even give time to let them think! I forgot they are all individuals, who have their own learning process and pace". Learning would be achieved. She further agreed that students were moving from the stage of "listen and practice" to positive peer interaction and increase students' learning beliefs. However, the impression on students' passive learning attitude still remains as her concern. At last, subject's teaching professional development and growth has been improved through out this study as well as the level of self-efficiency.

4.2 Teacher's role

Teacher's role had been changed from the knowledge deliverer into the communicator and distributor. From one of the interviews, subject described that "I used to use worksheets and teaching aid materials when I taught math, and used the lesson plans which provided by school. After I joined the MTPDC session, I was introduced a new way to assess my students. I like the way students can describe what they have learned in their own interpretations. I thought, it might be a good teaching strategy for me; I can teach math concepts in my own way to students. It is worth to try." Subject also gradually established her beliefs in systematic teaching in mathematics curriculum.

4.3 Subject teacher's self-confidence

Transaction of the subject's teaching style was noticed during the data collection. Subject used to implement prefabricated work sheets and handouts from bookshops as her teaching aids. However, during the process of the transaction, she rearranged her teaching material and used the concept map approach in her preparation and teaching (Figure 1.).

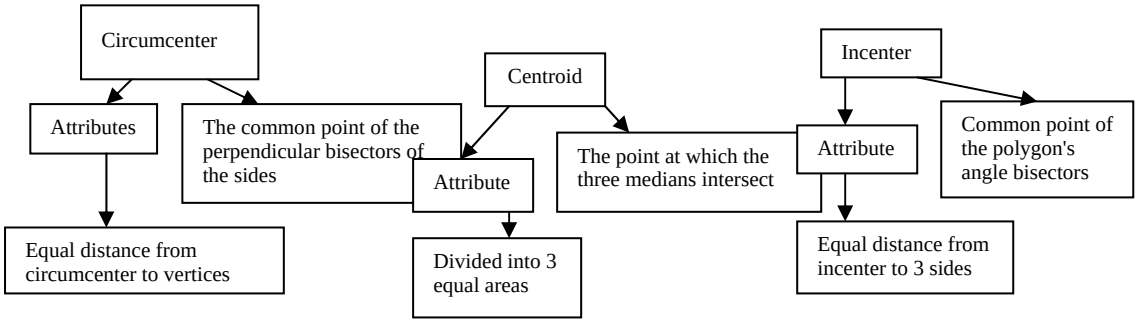

Figure 1: The concept map of triangle's circumcenter, incenter, and centroid

In her past teaching experience, subject kept demonstrating the correct solution to students regarding mathematics problems, but ignored the reason why students made mistakes. Concept maps provided an opportunity to conduct her teaching systematically. She said " I feel more confidence when teach now. When I have my concept map teaching materials prepared, I feel I can do everything!" She adjusted her teaching style by assessing student's academic achievement, feedbacks, and her own reflects. Her teaching strategies and classroom environment has been focused on leading and helping students in their learning.

5 Conclusion

The findings of this study suggested that subject teacher's beliefs had gradually changed through this research. The teacher's role had also changed from a knowledge deliverer into a communicator and distributor. Through the discussion and sharing session with the professional growth community, the level of self-confidence within

subject had increased regarding her mathematics teaching as well as her teaching effectiveness. The concept maps approach allows the subject to move away from the rote memorization of information toward the facilitation of meaningful learning.

In addition, researchers also notice the transaction of subject's teaching preparation. Toward the end of this research, subject tended to give up prefabricated teaching material as typical textbook. By adopting the concept maps and its principles, subject evolved related topics, which enhanced students' understanding of primary teaching topic in mathematics. Subject also reflected that concept maps helped her adjust her instruction by identifying individual learning barrier.

Over all, researchers discovered that using concept maps as a tool elevated subject's self-confidence in teaching and flexibility of her content preparation according to different topics and skill level of students. When instructional problem encountered, teachers who participated in MTPDC sessions were more capable in recalling and applying their own and or group experiences as potential solutions. These recalling processes allowed MTPDC participating teachers to further improve their professional knowledge development (Lin, 1998). Furthermore, subject embraced the idea of concept maps and developed a double-layer questionnaire as evaluation tool for the learning of her students. This is a concrete approach in mathematics teaching not only for professional development and growth but also consolidate teaching beliefs and self-confidence.

6. References

Angelo, T., & Cross, P.K. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). San Francisco: Jossey-Bass.

Bartels, B. (1995). Promoting mathematics connections with concept mapping. *Mathematics Teaching in the Middle School*, 1,542-549.

Beyerbach, B. (1988). Developing a technical vocabulary on teacher planning: Preservice teachers' concept maps. Teaching & Teacher Education, 4, 339347.

Bolte, L. A. (1999). Using Concept Maps and Interpretive Essays for Assessment in Mathematics. School Science & Mathematics, 99(1), 19-31.

Cooney, T. J. (1994). Research and teacher education: In search of common ground. Journal for Research in Mathematics education, 25,608-636.

Fennema, E., Franke, M. L., Carpenter, T. P. & Carey, D. A. (1993). Using children's mathematical knowledge in instruction. American Educational Research Journal, 30, 555-583.

Geddis, A. N. (1993a). Transforming subject-matter knowledge: The role of pedagogical content knowledge in learning to reflect on teaching. Int. J. Sci. Edu. 15, 673-683.

Geddis, A. N. (1993b). Transforming content knowledge: Learning to teach about isotopes. Science Education, 77, 575-591.

Grant, T. J., Hiebert, J. & Wearne, D. (1998). Observing and teaching reform-minded lessons: What do teacher see? Journal of Mathematics Teacher Education, 1(2), 217-236.

Heaton, R.M.& Lambert, M. (1993). Learning to hear voices: inventing a new pedagogy of teacher education. In D.K. Cohen, M. W. McLaughlin, & J. E. Talbert (Eds.), Teaching for Understanding (pp.43-83). San Francisco: Jossey-Bass Publishers.

Kennedy, M. (1990). A survey of recent literature on teachers' subject matter knowledge. East Lansing, MI: National Center for Research on Teacher Education.

Kinchin, I. M., & Hay, D. B. (2000). How a qualitative approach to concept map analysis can be used to aid learning by illustrating. Educational Research, 42(1), 43-58.

Lee, C. C. (1994). A case study of a junior high school teacher's beliefs in science teaching. Unpublished master theses, National Kaohsiung Normal University, Kaohsiung, Taiwan.

Lin, F. L. (1998). Student teachers' preconceptions of mathematics teaching and the relationship to their prior mathematics learning in Taiwan. Chinese Journal of Science Education, 3(6), 219-254.

Mansfield, H., & Happs, J. (1991). Concept maps. Australian Mathematics Teacher, 47(3), 30-33.

Mathematical Sciences Education Board and National Research Council. (1989). Everybody Counts: A Report to the Nation on the Future of Mathematics Education. Washington DC: National Academy Press.

Novak, J. D. (1984). Learning how to learn. New York: Cambridge University Press.

Novak, J. D. (1991). Clarify with concept maps. Science Teacher, 58 (7), 44-49.

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. Science Education, 86(4), 548-572.

Novak, J. D. (2004). Reflections on a half-century of thinking in science education and research: Implications from a twelve-year longitudinal study of children's learning. Canadian Journal of Science, Mathematics, & Technology, 4(1), 23-42.

Quinn, H. J., Mintzes, J. J., & Laws, R. A. (2004). Successive concept mapping. Journal of College Science Teaching, 33 (3), 12-17.

Ritchie, D., & Volkl, C. (2000). Effectiveness of two generative learning strategies in the science classroom. School Science & Mathematics, 100(2), 83-90.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57, 1-22

Simon, M. A., & Schifter, D. (1991). Towards a constructivist perspective: an intervention study of mathematics teacher development. Educational Studies in Mathematics, 22, 309-331.

Tsai, C.C., Lin, S.S.J., & Yuan, S.M. (2001). Students' use of web-based concept map testing and strategies for learning. Journal of Computer Assisted Learning, 17(1), 72-85.