

Session Title:

Concept Maps for Assessing Teacher Learning and Faculty Professional Development

MSP Project Name:

CEEMS: Cincinnati Engineering Enhanced Mathematics and Science Program

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Project Session**Strand 3****Summary:**

In order to improve the impact of professional development programs for pre and in-service teachers, university STEM faculty need to be able to deliver pedagogically sound instruction for teachers. However this is rarely an identified area for research and change. In this presentation we share how we used pre and post concepts mapping activities to assess the knowledge development of the teachers. We discuss the quantitative scoring system detailed by West et. al. (2000) to analyze the maps and the strengths and limitations of this method. Finally we discuss how we used the maps to provide feedback to the faculty on the knowledge change of the teachers in the summer session.

The session will be framed by the following questions:

- a) What can be learned by using pre and post-concept maps to understand the knowledge change of the participants?
- b) How can the use of the concept maps be improved for future evaluation?
- c) How can the concept maps be used to help STEM faculty develop their understanding of learning?

The learning outcomes of this session for participant will include:

- a) An understanding of the use of concept maps as measure of knowledge and learning.
- b) A simulated experience with concept mapping and analyzing concept maps.
- c) Details of the strengths and limitations of concept maps in PD situations.

The use of concept maps as an assessment tool is supported by research demonstrating benefits to both pre-service teachers and their instructors (Novak, 1990; Novak & Gowin, 1984). Novak (1990) believes concept mapping allows for pre-service teachers to transform their learning away from rote memorization practices and more toward “meaningful” learning. As part of the process of constructing “meaningful learning,” the learner must see value in the learning process and be able to connect the new knowledge being presented to existing knowledge (Novak, 1984). Pre-service teachers that have

experience using concept maps as a learning tool gain more confidence in using this metacognitive assessment within their students (Novak, 1990).

For instructors concept maps can help to identify students' misconceptions and serve as an organizational tool prior to teaching the lesson (Novak, 1984, 1998). Novak (1984) believes one of the reasons for ineffective school instruction could be linked to the instructors because they rarely sort out important concepts before they teach a lesson and do not attempt to recognize hierarchical relationships between the concepts being taught to their students.

The use of concept mapping as an assessment of students' content knowledge and understanding has been explored in multiple disciplines, including chemistry, psychology, nursing, pediatrics and industrial engineering (Besterfield-Sacre, 2004; Hsu, 2004; Jacobs-Lawson & Hershey, 2002; Regis & Albertazzi, 1996; West, Pomeroy, Park, Gerstenberger & Sandoval, 2000) and has been found to be a valid form of assessment when measuring knowledge change during instructional sessions (Jacobs-Lawson and Hershey, 2002; Srinivasan, M., McElvany, M., Shay, J., Shavelson, R., & West, D., 2008; West et al., 2000).

The concept map data was generated by the 27 pre and in-service teachers in the program. The pre-assessment concept maps were completed on the first day of the summer class and the post-assessments on the second to last day of class in which each teacher was registered. The 27 teacher participants each took only one of the four elective classes. The numbers of participants in each class was varied, with 3 participating in the computer engineering courses, 6 in the biological science course, 7 in the earth systems (geology) course and the remaining 11 in a physical science course. The concept map assessments were given by the faculty instructor and participants had 20 minutes to individually complete the maps. The pre and post assessments were collected, photocopied and analyzed as described in the next section.

The teachers' concept maps were analyzed following the scoring technique used by West et al. (2000). In the West et al. (2000) study of 33 pediatric residents, pre and post assessments were quantitatively scored in four categories: *hierarchies*, *concept links*, *cross-links*, and *examples*. A *concept*, as defined by West et al. (2000), is "a perceived regularity in events or objects designated by a label and, when depicted on a map, enclosed with a circle" (p. 1106). The *hierarchy* of a concept map is based on direction of the arrows and the individual concepts' arrangement within the map, with the most general and most inclusive concepts typically being placed at the top of the map (West et al., 2000). Each concept is also linked with an arrow, thus forming a *concept link* (West et al., 2000). *Cross-links* are denoted connections between concepts located in different domains and help to measure map complexity (West et al., 2000).

Pre and post concept maps in an additional course, taught by a high school teacher who taught an engineering class at her school, were used to practice the scoring process. Each of the foundations of engineering pre and post concept maps were scored by one of the

study's authors using a quantitative value system devised by West et al. (2008). The maps authors' anonymity was maintained by using a numbered coding system completed by another researcher. The West et al. (2000) scoring system is as follows: valid concept links are awarded 2 points, cross-links are awarded 10 points, hierarchical levels are awarded 5 points, and examples are awarded 1 point. If the link or concept was invalid (incorrect), 0 points were awarded. The sub-score for each of the four categories were recorded for authors' pre and post concept map assessments and the sum of each sub-score was totaled to determine a total concept map score (West et al., 2000).

Once the concept maps were analyzed quantitatively, one of the researchers met with the higher education faculty to share the results. In these interviews the analysis of the quantitative scores was discussed and then samples of the pre and post concept maps from their classes were shared. The faculty were asked about a) the changes they saw in the structure of the pre and post concept maps; b) how accurately the faculty member felt the maps represented how they saw the content arranged; c) if they felt the maps represented what they wanted to the teacher participants to learn. These interviews were taped and transcribed for analysis. The feedback from the interviews and discussions was used to improve the structure of the concept map assessment and focus the faculty on thinking about the relationship between major concepts to be learned in their courses and how these concepts are organized.

Our study using concept maps provides support for improving instruction in the areas teaching and learning of science by: 1) validating the use of concept maps as a formative instructional practice for measuring students' content knowledge change in the area of science, 2) supporting Novak's (1991) findings that concept maps allow instructors to gain new insight into the concepts in which they are teaching, 3) allowing instructors to develop a formative instructional tool to identify and address student misconceptions throughout the learning process, 4) validating the importance of reflective pedagogical practices by providing opportunities for instructors to participate in reflective dialogue and activities that will enhance their pedagogy and instructional practices for the science pre-service teachers by which they influence.

In addition, we believe it is essential in professional development activities of this kind, where university faculty teach classes for in-service and pre-service teachers, that attention be paid to the pedagogical quality of the instruction presented to the teachers. In a multi-year project there should be intentional opportunities to help faculty from the disciplines to engage in dialogue about teaching and learning and reflect on the impact of their own practice in a formal fashion. This faculty professional development needs to be an intended consequence of participation in grant funded activities if change in instruction is to have a sustained impact on STEM education.

In this session we will discuss the potential and limitations we found using concept maps for summative (participant learning) and formative (feedback and discussion with faculty) evaluation. We will share, and seek to elicit from other projects, ways to improve the use of the concept maps as a measure of learning. We will also discuss the role of

faculty professional development within our MSP and how the concept maps can be used to support faculty PD.

The session will provide a brief overview to concept mapping in general and a detailed discussion of the West et. al, (2000) scoring of concept maps. We will engage the participants in a brief concept mapping activity using the format used for our pre and post assessments. The participants can use their own developed concept maps to practice scoring, as well as compare with another participant what the organization and structure of the maps represents about content knowledge. We will then lead a discussion of the value of presenting the qualitative restructuring of knowledge as represented in the pre and post maps, the limitations of the implementation, and initial findings about the faculty responses to the concept maps from their courses.

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