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PROSPECTIVE TEACHERS’ KNOWLEDGE OF CONSTRUCTING CONCEPT MAPS

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Abstract. This paper presents an exploratory study that investigated prospective teachers’ knowledge of concept mapping. Current research emphasizes concept mapping as an important tool in the classroom for teaching, learning and assessment of student learning. Despite the large number of studies on K-12 students’ use of concept mapping, there are very few studies on prospective teachers’ knowledge of concept mapping, and thus, how they plan to use concept mapping as a future teaching and learning tool in classrooms. Data included prospective teachers’ concept maps on two science topics, narratives and interviews used to derive the perspectives that underscored the processes prospective teachers used to create their concept maps. Analysis of data revealed that prospective teachers possessed limited knowledge about: (1) the basic components of the structure and form of a concept map and (2) the processes involved in creating a concept map. The findings indicate that prospective teachers’ knowledge of concept mapping was superficial even though they claimed that they had used or were informed about concept mapping in K-12 classrooms. Additionally, the various structural forms of concept maps constructed by prospective teachers indicated that there was no uniformity in the processes leading to the construction of concept maps. Taken together, the findings suggest that teacher educators need to derive and assess their prospective teachers’ prior knowledge of concept mapping and then provide frameworks to guide their prospective teachers’ proper and acceptable use of concept mapping in their future classrooms.

1 Introduction

The use of concept mapping in classrooms for teaching, learning and assessment have been empirically studied and well documented in the literature. Scholars like Novak, Kinchin and others have investigated, discussed and are continuously building the knowledge on concept maps for the past two to three decades (Borda et al., 2009; Edmondson, 2000). Concept mapping has continuously been identified as an effective tool and technique for facilitating, capturing, eliciting and representing students’ conceptual understanding, cognitive structures and their meaning-making. Despite the extensive literature on concept mapping as an instructional tool, a learning tool and an assessment tool (Gouli, Gogoulou, & Grigoriadou, 2003; Hay, 2008; Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin et al., 2005) there is very limited literature on prospective teachers’ knowledge of constructing concept maps. Addressing this gap in the literature is important because prospective teachers themselves have been consumers of concept mapping during their K-12 experiences (Borda et al., 2009) and will become future users of concept mapping for instruction, learning and assessment. Most importantly, insights into prospective teachers’ knowledge of concept mapping can provide a window into what prospective teachers know and do not know about concept mapping. These insights are pertinent in shaping prospective teachers’ knowledge of concept mapping because “the structural complexity and propositional validity of concept maps is directly related to the knowledge used in creating the structure and upholding the quality of concept maps during the concept map preparation process” (Gerstner & Bogner 2009, p. 427). Additionally, teachers need to acquire this knowledge about concept mapping because both the structure and quality of concept maps reflect the credibility and validity of students’ understandings and it is the quality and structure expressed through concept maps during the process of concept mapping that provide the windows into students’ understanding (Mintzes, Wandersee, & Novak, 2001; Novak, 1984).

This paper details the collection and analysis of prospective teachers’ concept maps for two science topics: dissolving and density. The concept maps were analyzed for quality and structure to gather perspectives on prospective teachers’ knowledge of constructing concept maps. The propositional validity of the science content was not the focus of this study. Findings of the analyses and samples of concept maps drawn by prospective teachers are provided.

2 Review of Literature

A review of literature indicates that four distinct knowledge domains are necessary for constructing concept maps in classrooms. The four knowledge domains include attributes of concept maps such as concepts and linking phrases, hierarchical/graphical structure of the map, concept map quality, and the extent to which construction of the concept map was self-directed (i.e., c- map or s-map).

The first domain is the knowledge of the attributes of concept maps. The five major attributes of the traditional concept map include the concepts/nodes/terms, directional linking lines, linking phrases, labeled lines and propositions (Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008). At the basic level, concept maps consist of subordinate concepts related to a superordinate concept, and connected to each other via links in a hierarchical form. At an advanced level the superordinate concept and/or subordinate concepts may be cross linked to illustrate in-depth or extensive relationships between concepts (Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008).

The second domain is the knowledge of the structure of concept maps. Literature indicates that the structure of concept maps can be typically categorized using two approaches: hierarchical and graphical. Basically, the hierarchical approach explicates the levels of knowledge, the number of single concepts, links between concepts, and cross links among concepts in a top-down fashion while the graphical approach explicates the level of meaningful conceptual understanding by advocating different levels of understanding to each overall shape. The graphical approach to concept maps qualitatively classifies concept maps as chain/linear, circular, hub/spoke, tree and network/net. Among these structures, the network/net is categorized as complex and indicating advanced and deep understanding of the interrelationships between the superordinate concept and the subordinate concepts through labeled links and cross links while the rest of the structures suggest simple associations between concepts (Kinchin, 2000; Yin et al., 2005; Yin & Shavelson, 2008).

The third domain is the knowledge of the quality of concept maps. Literature defines the quality of concept maps in a number of ways. First, a quality map or “good” map is defined as one that contains one superordinate concept linked and/or cross-linked with appropriate linking words/phrases to at least 20 subordinate concepts forming valid, logical, and scientifically correct propositions and collectively reflecting a hierarchical structure (Novak & Cañas, 2006; 2008) or graphical structure (Kinchin, 2000; Yin et al., 2005; Yin & Shavelson, 2008). This quality of a concept map is dependent on the validity of linkages and propositions and also reflects the concept-map structure complexity (Meagher, 2009). Second, a quality map is one that takes on the form of a net structure that contains valid, logical and scientifically accepted linked and/or cross linked propositions representing meaningful learning and conceptual understanding (Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008). In contrast, “poor” quality maps are those “those with few nodes, weak linkages and indistinct layering” (Johnstone & Otis, 2006, p. 89).

The fourth domain is the knowledge of the process of creating concept maps. Literature indicates that there are two dominant processes for creating concept maps in classrooms. One process is when students are totally responsible for creating the concept maps by themselves without the aid of subordinate concepts, and linking words/phrases: c-map (Yin et al., 2005; Yin & Shavelson, 2008). Johnstone and Otis (2006) describe this process of creating a concept map as placing “a key concept (or node) in the middle of a page” and surrounding the key concept with “closely related concepts (or nodes) linked by lines and some words to link them” and repeating the links and cross links until “a ‘picture’ of the knowledge and understanding” is revealed (p. 85). The other process is when students are provided with the structure of the concept map, the superordinate concept, the subordinate concepts, and linking words/phrases and are required to fill and complete the concept map to show the appropriate relational propositions: s-map (Yin et al., 2005; Yin & Shavelson, 2008).

3 Synthesis and Research Question

The review of literature indicates that the process of constructing concept maps is dependent on the teachers’ knowledge of the four distinct domains that contribute to the quality and structure of the concept maps. These knowledge domains are important for teachers to know because these four domains underpin any activity where concept maps are used for instruction, learning and assessment (Wallace & Mintzes, 1990). This study is based on two suppositions First, the authors of the study argue that extensive utilization and prevalence of concept maps in K-12 classrooms (Borda et al., 2009) have provided prospective teachers with experiential knowledge on the process of creating concept maps and this knowledge will in turn become future pointers for the use of concept maps in their own classrooms. Second, the authors contend that prospective teachers’ concept maps will exhibit (1) the essential attributes of concept maps (the superordinate concept, subordinate concepts, directional linking lines, linking phrases, labeled lines and propositions); and, (2) quality in terms of network structures that contain complex interactions (labeled links and cross links). The research question that underscored this study was “How do prospective teachers’ concept maps reveal their knowledge of constructing concept maps?”

4 Methodology

4.1 Participants and Context

Participants for this study were 61 prospective teachers enrolled in four sections of an elementary science methods course at a large university in the southwest region of the United States. The participants were in their final semester of coursework prior to student teaching semester. All participants met requirements for admission to teacher education, which includes a minimum grade point average of 2.75. The minimum degree plan requirements for each participant includes 12 semester credits hours of science (four courses), selected from the biological sciences, chemistry, physics, geology, environmental science or astronomy.

4.2 Data Collection and Analysis

Two sets of concept maps were collected from each participant at two points in the 15 week semester. The pre- and post- concept maps on dissolving were collected on the fourth and fifth week respectively and the density concept maps were collected on the eighth and ninth week respectively. Participants were given the following instructions before they created their concept maps for dissolving and density: “Construct a concept map for dissolving” and “Construct a concept map for density”. For three sections of the methods course both pre- and post- maps were collected while for one section only pre-concept maps were collected. A total of 229 concept maps were collected while 12 constructions were rejected because they did not resemble the traditional concept map.

Each concept map was analyzed for its correlation to the attributes of a concept map, and for quality and structure. Initially, the first domain of knowledge for each concept map was analyzed for the presence and/or absence of the superordinate concept, subordinates concepts, linking lines, linking phrases, labeled lines and propositions. Next, each concept map was analyzed for the second domain of knowledge; that is the concept maps were examined for the presence of a graphical (linear, circular, hub, tree and network) or hierarchical structure; and for the presence and/or absence of cross links. The third domain of knowledge is about the quality of the concept, therefore maps were examined for net structures that contained directional links and cross links. On identification of each of these features, a quantification of these features was carried out to provide percentages for the presence of each concept map element in domain one and also for each type of graphical or hierarchical structure.

5 Findings

Analysis of data revealed that out of the 229 concept maps collected only 208 or 91% of the concept maps exhibited some of the essential attributes of concept maps. In all, these 208 concept maps only contained the superordinate concept, subordinates concepts, and linking lines but no directionality and linking phrases at all (see Figure 1 for examples). That is, these 208 concepts did not have labeled lines and thus, it was impossible to validate propositions as scientifically correct. Data also revealed that only 25 or 11% of the concept maps exhibited a network structure while 83 or 33% of concept maps had a hub structure and 80 or 35% of the concept maps had a tree structure (see Figure 1 for examples). Analysis also indicated that only 33 or 14% of the 229 concept maps exhibited cross links (Figure 2). The 12 rejected constructions took the form of pictures and Venn diagrams (Figure 3).

Figure 1. Samples of hub and tree concept maps

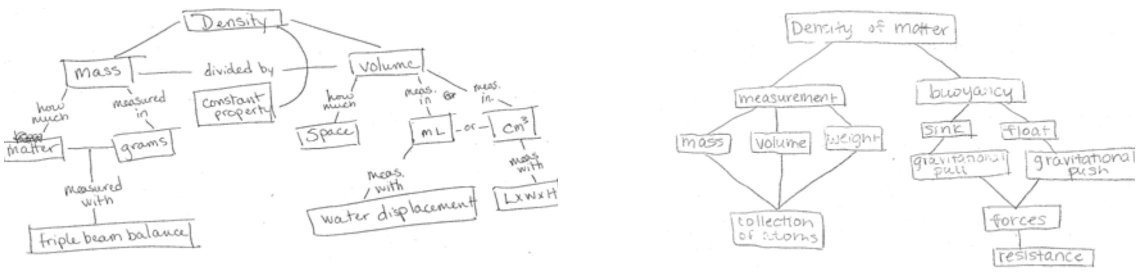

Figure 2. Samples of concept maps with cross links

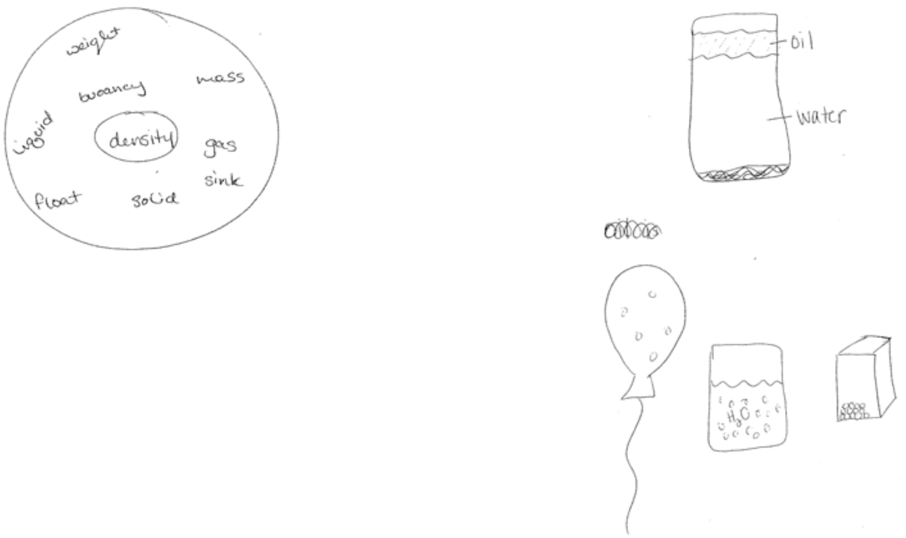

Figure 3. Samples of rejected "concept" maps

6 Summary

The findings of the study indicate that participants were aware of the basic features of concept maps. That is, participants' knowledge of the attributes of concept maps was limited to the superordinate concept, subordinate concepts, and linking lines but they were unaware of the importance of linking lines and phrases and/or directional lines in describing the relationship between the superordinate concept and the subordinate concepts (Yin & Shavelson, 2008). Even though this study did not look at the validity of propositions, it was evident that an analysis of the validity of propositions was impossible without linking lines and phrases and/or labeled lines.

Findings also indicated that participants in this study were comfortable in creating concept maps that were predominantly hub graphical and/or tree graphical structures. These graphical structures cohere with what Kinchin and Hay (2000) contend as concept maps that exhibit simple associations between concepts, lack complex interactions, lack map integrity, and exhibit limited conceptual development. The limited number of concept maps with cross links or network graphical structures suggest that participants are unaware a quality map is one that takes the form of a net structure and contains valid, logical and scientifically accepted linked and/or cross linked propositions representing meaningful learning and conceptual understanding (Johnstone & Otis, 2006; Kinchin, 2000; Novak & Cañas, 2006; 2008; Yin & Shavelson, 2008).

One important implication for teacher educators is the need to derive prospective teachers' prior knowledge of concept maps and the process of concept mapping during teacher education courses. This will help to reveal prospective teachers' knowledge or limited knowledge of creating concept maps so as to pinpoint areas of concern and thus, reshape their knowledge base of concept mapping. Finally, teacher educators, professional development instructors and teachers need to emphasize the knowledge domains that underscore the process of constructing concept maps so that the students and/or consumers to whom they introduce and use concept mapping can understand and apply the quality standards required to produce concept maps that are conducive to learning and all the potential benefits that the literature on concept maps extols.

7 References

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