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Effects of teaching concept mapping using practice, feedback, and relational framing

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ABSTRACT

Although concept mapping remains widely used in education, there is little research showing how best to teach it. We investigated if practice, feedback, and knowledge of relational framing help improve students' concept mapping skills over time. Four online graduate courses at two universities were randomly assigned to one of two teaching conditions: a traditional concept map teaching strategy or traditional plus relational framing teaching strategy. Students in each course created three concept maps over three weeks following repeated instruction and instructor feedback. Repeated practice and feedback improved the structural quality of students' concept maps, as well as the number of autobiographical elaborations within those maps. Teaching strategy moderated the effect of practice and feedback on the relational quality of students' maps. Relational scores in relational framing groups improved over time, whereas those in the traditional groups remained unchanged. Implications for teaching concept mapping are discussed.

As concept mapping becomes an increasingly popular activity for teaching, learning and assessment, educators must ensure they are introducing it to students in a way that best prepares them for success. A skill like any other, concept mapping requires certain parts be used and processes followed for students to realize its full potential. Sometimes this requires considerable effort from both students and educators. Consider the terminology involved in simply explaining the parts and processes of a concept map to students. One might say that a concept map is a graphical tool for representing a set of concept meanings within a framework of propositions (Cañas & Novak, 2009).

To create propositions, concepts are placed within circles or squares and related using arrows or lines called crosslinks, which are then labeled with linking words to describe the relationship between the two concepts (see Fig. 1). Within this admittedly rudimentary explanation are four requisite terms: concepts, crosslinks, linking words, and propositions.

After describing these parts, educators might proceed to explain how students' concept mapping should follow three processes: *subsumption, progressive differentiation,* and *integrative reconciliation* (Ausubel, 2000). During subsumption, specific concepts are incorporated beneath broader concepts, creating a hierarchy of knowledge structures and understanding. Each concept is then divided into increasingly finer components through a process called progressive differentiation. To form unique and sometimes unexpected relationships between concepts, students then relate concepts horizontally across their maps using a process called integrative reconciliation. Similarly, these processes introduce their own novel terminology and, for some students, likely depict an unfamiliar way of thinking and learning (Silverthorn, 1993). Given such challenges, educators may wonder if there are more effective ways to introduce students to concept mapping.

The intricacies of concept mapping emerge from Ausubel's (2000) assimilation theory of meaningful learning. Ausubel argued that people think and learn by relating concepts within what he called a cognitive structure, that is, a person's “organization, stability, and clarity of knowledge in a particular subject matter field at any given time (Ausubel, 1963, p. 217). He called this process *assimilation*, which he later clarified as the tendency of learners to relate new ideas to established ones in order to reduce the meaning of the new idea to that of the more established idea (Ausubel, 1968). Using this process, Ausubel described how students learn concepts meaningfully and construct knowledge structures from novel and familiar concepts. Principally, he argued, this occurs through the aforementioned processes of subsumption, progressive differentiation, and integrative reconciliation. During subsumption, learners organize knowledge hierarchically so that new knowledge relates to prior knowledge on a continuum of general to specific. During progressive differentiation, learners divide concepts into increasingly detailed and specific components through a

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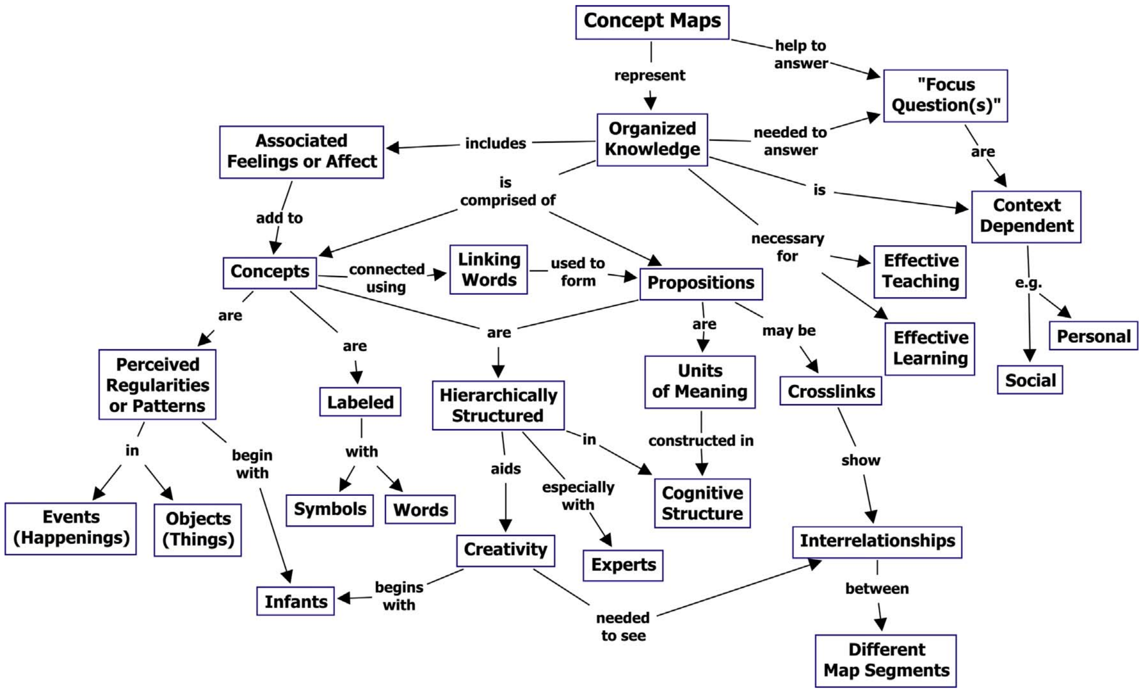

Fig. 1. A concept map showing the key features of concept maps (Novak & Cañas, 2006, used with permission).

process similar to analysis. And during integrative reconciliation, learners relate concepts in unique ways through a process similar to synthesis.

Novak and Gowin (1984) fashioned concept maps as a visual tool for operationalizing Ausubel's theory. Ausubel's ideas on subsumption, progressive differentiation, and integrative reconciliation became guidelines for the ideal structure, processes, and parts of a concept map. Consider Fig. 1, for instance. One can see the concept of *effective learning* subsumed using cross links and linking words beneath the concept of *organized knowledge*. Lower in the map, the concept *hierarchically structured* is progressively differentiated into *creativity*, *experts*, and *cognitive structures*. And still lower in the map, one can see Ausubel's idea of integrative reconciliation through the horizontal cross map relationship between *creativity* and *interrelationships*. Additionally, as a way to illustrate Ausubel's ideas on assimilating novel concepts into existing cognitive structures, educators often encourage learners to include personal experience in their maps (Daley, 2010).

Although the underlying theory and subsequent parts and processes of concept maps can initially be challenging for students to learn, they remain widely used in teaching disciplines such as chemistry (Lopez et al., 2011), engineering (Daugherty, Custer, & Dixon, 2012), natural science (Hwang, Yang, & Wang, 2013), math (Vagliardo, 2004), physics (Alias & Tukiran, 2006); photography (Gimena, 2004), writing (Straubel, 2006), pharmaceutical science (Hill, 2006), nursing (Daley, Shaw, Balistrieri, Glasenapp, & Piacentine, 1999), and medicine (Torre, Durning, & Daley, 2013). Concept mapping has been used to assess learning (West, Park, Pomeroy, & Sandoval, 2002), foster meaningful learning (Novak, 1990), promote curriculum development (Edmondson, 1995; Riesco, Fondon, & Alvarez, 2008), develop instructional strategy (Stoddart, 2006), improve problem solving (González, Palencia, Umaña, Galindo, & Villafrade, 2008), and teach specific content (Kyrö, Seikkula-Leino, & Mylläri, 2008).

Importantly, researchers have found that concept maps are commonly used to assess student learning, knowledge acquisition, and knowledge organization (Daley & Torre, 2010; Torre et al., 2013; Knollmann-Ritschel & Durning, 2015; West et al., 2002). In a review of the literature, Ruiz-Primo (2004) concluded that concept maps were valid and reliable measures of how well students organize the declarative knowledge in a domain. McClure, Sonak, and Suen (1999) found that, when educators used certain scoring methods, concept maps were valid and reliable measures of not only students' knowledge organization but also their retention of course content. Additionally, Stoddart, Abrams, Gasper, and Canaday (2000) demonstrated that concept maps were practical, valid, and reliable measures of a student's understanding of a given domain. Taken together, these findings suggest that concept maps measure aspects of learning that alone illustrate changes in a student's understanding resulting from instruction. Accordingly, they require no correlative performance measures to establish their validity as a measure of learning.

Despite these established uses, few researchers have broached the best way to teach concept mapping. Of those who have, Silverthorn (1993) has suggested educators provide models and explain the parts and structure of a concept map before asking students to create their own. Cañas et al. (2003) have recommended educators supplement this approach, when warranted, with computer support. Some have compared different ways of teaching concept mapping to students. Yin, Vanides, Ruiz-Primo, Ayala, and Shavelson (2005), for instance, found that when students are taught to use ready-made linking phrases rather than their own, their concept maps are structurally less complex and composed of fewer propositions.

With little research available, it is not surprising that educators generally adopt didactic approaches to inform students of the theory, parts, and processes involved in concept mapping. Some may facilitate an initial period of guided practice with time for questions (McClure et al., 1999). In our experience, such approaches initially produce maps of mostly linear constructions linking one concept to another. Students often show improved progressive differentiation and integrative reconciliation, though, when given repeated opportunities for practice and feedback. For numerous skills, prolonged practice that is goal oriented and incrementally refocused has emerged as a principal contributing factor in exemplary performance (Ericsson & Lehmann, 1996; Ericsson, 2006; McGaghie, Issenberg, Petrusa, & Scalese, 2006), particularly when coupled with immediate, unambiguous, and regular feedback (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2006; Mahmood & Darzi, 2004). But for concept mapping, research has not confirmed this. Are practice and feedback critical to learning concept