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Concept Mapping: A Strategy to Support the Development of Practice, Research, and Theory Within Human Resource Development

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Abstract

The purpose of this integrative literature review is to summarize research on concept mapping and to offer ideas on how concept mapping can facilitate practice, research, and theory development within human resource development. In this review, more than 300 articles, written in both English and Spanish, presented at two different concept mapping conferences were reviewed. Six researchers reviewed the articles and created a matrix outlining the research studies, the methods, the findings, and the implications. This matrix was then used to conduct an in-depth analysis and identify six overall themes of the research presented. These themes were identified as (a) teaching and learning, (b) assessment and scoring, (c) knowledge development, (d) software development, (e) professional development, and (f) research methods. Finally, the identified themes were used to advance implications for the use of concept mapping within human resource development.

Keywords

Concept mapping, theory development, research development, critical thinking

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Concept mapping is a teaching, learning, and research strategy that has been in use within educational settings for more than 25 years. There is a large research base supporting the use of concept mapping in both education and business organizations. In addition, there have been numerous literature reviews and meta-analyses on the effectiveness of concept mapping in education (Cañas et al., 2003; Nesbit & Adesope, 2006). However, the application of concept mapping to practice, research, and theory development within the field of human resource development (HRD) has not been articulated.

Torraco (2005) indicates that “an integrative literature review of a mature topic addresses the need for a review, critique, and the potential reconceptualization of the expanding and more diversified knowledge base of the topic as it continues to develop” (p. 357). Because concept mapping is a mature topic, the purpose of this integrative literature review is to evaluate the most recent research in concept mapping and draw implications for the field of human resource development.

Concept Maps: What Are They?

Concept maps were originally created at Cornell University as a research tool by Dr. Joseph Novak. Novak and his colleagues were conducting a 12-year longitudinal study on how children learn science concepts. In this study, “twenty-eight lessons were developed that dealt with the particulate nature of matter, energy types and energy transformations, energy utilization in living things, and other related ideas” (Novak, 2004, p. 458). Children completed audio-tutorial lessons on these topics and then the research team interviewed these students about their learning. With hundreds of interview tapes to analyze, the research team began looking for alternative data analysis strategies. As Novak (2004) indicates, “in our discussions, the idea developed to translate interview transcripts into a hierarchical structure of concepts and relationships between concepts, that is, propositions. The ideas developed into the invention of a tool we now call the *concept map*” (p. 460). According to Novak and Gowin (1984), a concept map is “a schematic device for representing a set of concept meanings embedded in a framework of propositions” (p. 15). Concept maps are pictures, designed with words in boxes that represent concepts (see Figure 1). These concepts are then connected with linking words to form propositional statements. The resulting concept map demonstrates the existing cognitive structure of the person creating it. As the developer of the map learns additional concepts, they are added to the existing cognitive structure, gradually expanding and deepening the meaning demonstrated on the map. Concept maps have been used to facilitate individual learning, but they have also been used to identify group learning and group processes, as well as knowledge management systems within organizations. Figure 1 depicts a concept map of the theoretical ideas related to the construction of maps. What can be seen in Figure 1 is that lower order concepts are subsumed under higher order concepts; these concepts are then progressively differentiated into finer and finer parts, and finally the concepts are linked together horizontally to demonstrate an integration of ideas. To create a concept map, the person developing the map usually starts with the major concepts, breaks those down into component parts, and then looks for linking words to tie the concepts together. These links are made both in a vertical and horizontal fashion.

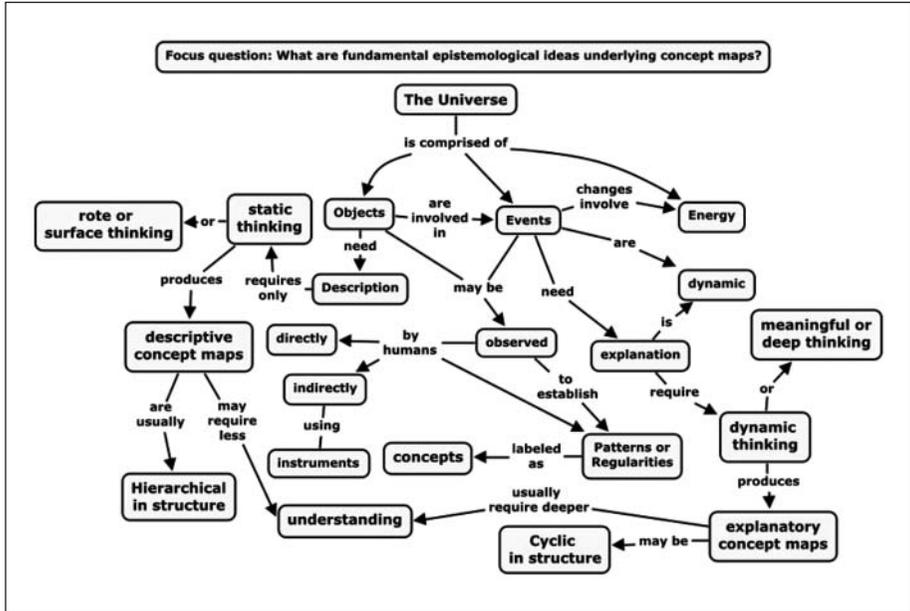


Figure 1. A concept map showing the key theoretical ideas underlying construction and use of concept maps
 Source: Reprinted with permission from Cañas and Novak (2006, p. 495).

As the use of concept maps grew, Novak and colleagues initiated a partnership with the Institute for Human and Machine Cognition (IHMC). IHMC developed CmapTools, a software program for creating computer-generated concept maps. Recently, IHMC has continued the development of CmapTools and facilitated the creation of the International Concept Mapping Conference (CMC). This conference is held every other year and currently serves as the primary vehicle by which the most recent and up-to-date research on concept mapping has been disseminated.

Why Integrate Concept Maps in Human Resource Development?

It is our view that practice, research, and theory development in the field of HRD can be enhanced by drawing on and integrating concepts and constructs from across various knowledge domains. As Yorks (2008) noted,

New theory needs to be justified on the grounds of offering potential answers to new and interesting questions not brought to light by existing theory. This justification rests on the existing literature that is being either critiqued or integrated in a new and provocative way. The same is true of integrative literature reviews; what new insights are provided, new questions asked, or answers to

provocative questions suggested by integrating previously separate literature streams. (pp. 139-140)

By conducting an integrative review of concept mapping research, we offer new ideas from a separate literature stream to the field of human resource development. To determine the necessity of conducting a review of the research conferences on concept mapping, we searched existing databases (ERIC, PsychLit, Academic Search) for articles linking concept maps and human resource development. In this search, we found three articles published in the past 10 years on this topic. Two articles were from symposium presentations at the Academy of Human Resource Development Conference. One article (McGoldrick, Steward, & Watson, 2001) discussed using concept maps in theorizing HRD within the United Kingdom, and the second (Daley, 2002) discussed teaching graduate students in HRD by using concept maps. The third article (Fornes, Rocco, & Wollard, 2008) used concept mapping while conducting an integrative literature review to assist in developing a conceptual model of workplace commitment. As one can see, integrating concept maps into research and theory development within HRD is only beginning. Because there were so few articles connecting concept mapping and HRD, we chose to review the concept mapping conference literature as a way to generate new ideas and potential connections to the field of HRD.

Research Questions

The following questions were advanced to guide this integrative literature review:

1. What are the overall research themes that have been presented at the International Concept Mapping Conferences?
2. Based on these themes, what implications does concept mapping have for future practice, research, and theory development in HRD?

Method

According to Creswell (2008), a thematic integrative literature review is one in which the researcher uses the literature to identify themes and patterns in areas of research, and then discusses those themes with general reference to the studies from which they came. Drawing from the conference website and published proceedings, three English-speaking and three Spanish/English-speaking researchers conducted a thematic literature review of the articles from the CMC proceedings. The researchers reviewed more than 300 articles in English or Spanish. The articles reviewed were from 38 different countries.

During this review, each researcher contributed to a matrix that specified the title of the article, the authors, the language of the article, the country(ies) of the researcher(s), the year of publication, a short summary of the article, the methods, the findings, and the implications for practice and research. From this matrix, initial themes were

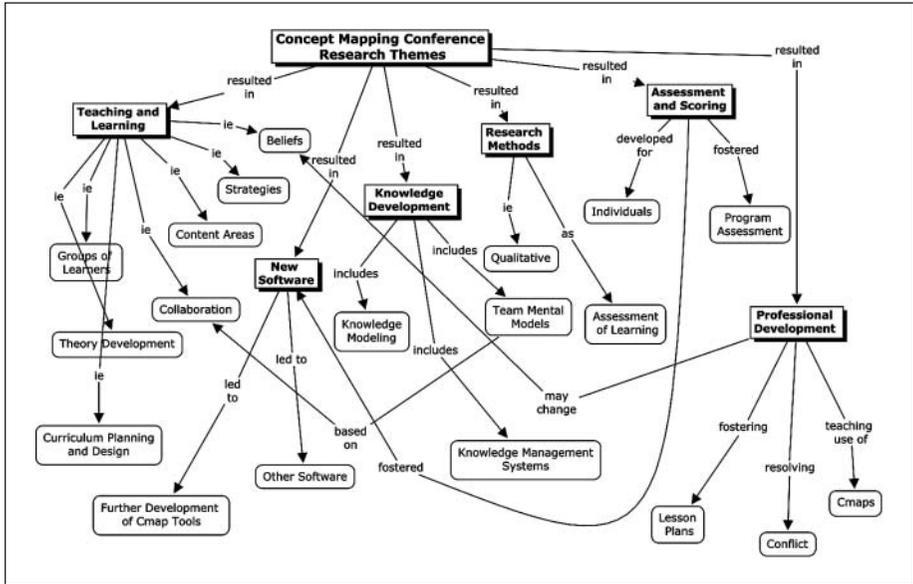


Figure 2. Concept map of research themes identified in the International Concept Mapping Conferences

identified that represented the major research categories presented at the 2004 and 2006 CMCs. The researchers then met to discuss, refine, and modify the initial themes created and to agree on the final list of six themes. A concept map (Figure 2) was created identifying these major themes. Figure 2 represents a synthesis of the CMC literature, and as Doty and Glick (1994, as cited in Torracco, 2005) indicate, “a taxonomy or other conceptual classification of constructs is often developed as a means to classify previous research . . . [to] lay the foundation for new theorizing” (p. 363). Following the 2008 CMC, the researchers looked for consistency by comparing the articles presented in 2008 to the themes identified here.

Research Themes Identified

According to Mandl and Fischer (2000), there are currently “three major fields where concept mapping is used, namely as a teach-and-learn strategy tool, a cooperation process application, and as a tool for knowledge gathering, diagnosis, and modeling” (as cited in Fourie, Schilawa, & Cloete, 2004, pp. 249-250). Based on our review of the CMC proceedings, it is evident that the use of concept maps has expanded into many other areas as well. As shown in Figure 2, we identified the following areas where concept mapping was being investigated in the CMC proceedings: teaching and learning, assessment and scoring, knowledge development, creation and expansion of software, research methods, and professional development. In the next section of this

article, we discuss five of these themes. The sixth theme of creation and expansion of software for concept mapping was deemed more important for concept mapping researchers and not immediately applicable to HRD. However, HRD may benefit in the years to come from these new software developments.

Teaching and Learning

The largest number of CMC research articles was generated around the theme of teaching and learning. Overall, these articles identified innovative ways of using concept maps for student learning. For example, concept maps have been used as advance organizers (Nathan & Kozminsky, 2004; Tavares, 2004), for educational group activities (Rojas-Drummond & Anzures, 2006), to produce a virtual magazine (Vargas, 2004), to improve reading and comprehension (Aránguiz, Berraondo, & de la Torre, 2004), to teach math (Bolte, 2006; Olivares, 2006; Pozueta Mendia, Guruceaga Zubillaga, & González García, 2006), as a research tool (Åhlberg, 2004), as part of sharing teaching experiences (Ramos, 2004), as a self-reflection and self-regulation tool (Hugo & Chrobak, 2004), and to do research and complete literature reviews (Tysick, 2004). In the next section of this article, we discuss examples of research articles that address specifics of teaching and learning.

Instructional strategies. For instructors, concept maps have been used as a tool to organize instruction and to gather student feedback on learning (Fonseca, Extremina, & Fonseca, 2004), to assess student word problems through action research (Prabhu, Elmesky, & Czarnocha, 2006), to prepare teachers through portfolios and course planning (Iuli, Wagle, & Voetterl, 2006), and to assess understanding of science concepts and science language production (Stoddart, 2006). Articles also described innovative methods for using concept maps: pictorial concept maps (nonhierarchical and with limited linking words) to provide medication instructions for patients who have chronic diseases and low literacy (Hill, 2006), crossword puzzles and concept mapping (Tifi, 2004), construction of relevant terms for googling using a concept map and keywords generated from main concepts (Leake et al., 2004), and creation of maps with aluminum foil as the connections promoted creativity (Lombardi & Tifi, 2004).

Beliefs. A few articles focused on teacher beliefs. Mellado, Silva, and Ruiz (2004) wrote about their use of concept maps in interviews as instruments of analysis of high school science teachers' understandings about their own teaching. Banet, Sánchez, and Valcárcel (2004) used concept maps for analysis and reflection of university teaching in order to identify the teaching characteristics and to allow instructors to critically analyze their own teaching practice. González, Bermejo, and Mellado (2004) described a longitudinal study comparing a high school biology teacher's thinking about teaching and learning through a questionnaire and concept map analysis.

Content areas. Articles focused on research on teaching and learning related to a variety of content areas. Some of the content areas included engineering (Feregrino-Hernández, Reza-García, Ortiz-Esquivel, Navarro-Clemente, & Domínguez-Pérez, 2006), math (Heinze-Fry, 2004; Oneca, Sanzol, & Poveda, 2006; Vagliardo, 2004),

physics (Alias & Tukiran, 2006; Valadares, Fonseca, & Soares, 2004), medical education (Illas, 2006), photography (Gimena, 2004), writing (Straubel, 2006a, 2006b), and pharmacy (Hill, 2006). Within business, concept maps were used to teach strategic intent (Fourie & Westhuizen, 2008), entrepreneurial behavior (Kyrö, Seikkula-Leino, & Mylläri, 2008), and business planning (Kyrö & Niskanen, 2008).

Groups of learners. Articles were written based on the study of different groups of learners ranging from kindergarten (Mancinelli, 2006), elementary (Aquilino & Venditti, 2006; Venditti & Sabba, 2006), undergraduate and graduate students, medical students, and business learners (Bowen, 2006).

Theory development. Some of the articles focused on theory development or analysis of existing theories in the use of concept maps. For example, Tamayo and Arroyo (2004) contended that concept maps are symbolic systems that represent a narrative and, therefore, can be interpreted. Tamayo (2004) stated that reading a concept map is not only a representation of a text, but also the text itself with cultural and symbolic characteristics. In 2006, Tamayo presented a theoretical study addressing the concept of immediate development zone by Novak as guiding the learning process and connecting concept maps within Vygotsky's social cultural theory. Several articles stressed the application of Reigeluth elaboration theory on the use of concept maps (Murillo, Zamora, Martinez, Alcalde, & Ballester, 2004; Pérez, Suero, Montanero, & Pardo, 2004; Solano, Pérez, & Suero, 2004). Kankkunen (2004) attempted to link Peirce's semiotic paradigm and concept mapping as a way to explain different levels of reasoning.

Collaboration. Collaboration has been a strong theme within the different articles for the conferences. Some articles suggested new methods for doing collaboration; others suggested new ways of looking at collaborations. Tifi and Lombardi (2006) described the WWMAPS, a community of education through collaborative concept mapping for primary and secondary schools across cultures to enhance multilingual skills. Åhlberg, Lehmuskallio, and Lehmuskallio (2006) proposed a global information system called NatureGate® that uses concept maps to explain ecologically, economically, and socially sustainable development. Khamesan and Hammond (2004) looked at synchronous collaborative concept mapping via text and text/audio enhancement with computers. Berionni and Baldón (2006) described how teachers in Italy launched an innovative project about community building across ages and cultures in science teaching with students 6 to 13 years old. Pérez Rodríguez, Suero López, Pardo Fernández, and Montanero Fernández (2006) showed the process of collaborative reconstruction of concept maps with future physics teachers. Ambel et al. (2004) described the development of a community of practice of concept mapping in Italy. The community aimed at structuring and organizing selective criteria in order to produce and make available documentation.

Curriculum planning and design. Concept maps have been used to plan and design curriculum using a variety of strategies. Vilela, Austrilino, and Costa (2004) used concept maps as a curriculum development tool by having a group of curriculum developers identify missing linkages, inconsistencies, false assumptions, and unrecognized relationships. Cantú, Farines, and Angotti (2004) described the use of concept maps to

generate a thematic approach to organizing curricula. Colli, Rossi, Giordani, and Montagna (2004) described methods instructors used to organize their curriculum using CmapTools to examine and explain ideas. Cabral, Zeve, Nicolao, and Amoretti (2004) described a method of using concept maps to organize webpages for distance learning courses. With the purpose of identifying major curricular issues in a graduate program in Turkey, Paykoç et al. (2004) described the use of a mind mapping process to brainstorm key issues and to evaluate the program. Bueno and García (2004) used document analysis through concept maps to compare methods used to determine the profile of the curriculum in the area of science in secondary education. Riveros, Castro, and Gutiérrez (2006) used concept maps to formulate, update, plan, and follow up on an engineering curriculum program.

As can be seen here, the vast majority of concept mapping research is concentrated in the area of teaching and learning and how one can incorporate concept mapping in teaching practices. It is our view that using concept maps to enhance student learning, across various disciplines, age groups, and content areas is well documented. And yet very few studies exist that demonstrate the use of concept maps in training and development within organizations. The field of HRD could be instrumental in researching how concept maps integrate with business thinking processes and other thinking and learning processes such as deep learning processes, developing mental models, and critical thinking. These types of higher level thinking abilities are essential to the next generation of HRD practitioners, and the field could benefit from a greater understanding of how to develop these high-level skills in graduate students as well as in employees.

In addition, HRD researchers could develop more studies in the area of group learning with concept maps. Studies have shown that shared mental models can develop through collaborative learning and from the interaction of individuals in the development of a group map. However, the processes that groups use to build from individual maps to a group map need more investigation. In addition, we need to understand more fully how teams and groups construct knowledge and then how that process of knowledge construction facilitates the performance of the group within an organization (see also Evans, Harper, & Jentsch, 2004). When groups and teams develop a shared mental model with concept maps, how does their performance compare to groups who have not engaged in this process?

Finally, longitudinal studies that assess the impact of concept maps on student or employee learning are virtually nonexistent. Creating longitudinal studies could assist HRD researchers to more fully understand the learning processes that underlie the development of expertise within organizations.

Assessment and Scoring

The second theme identified in this literature review was assessment and scoring. Concept map research was being conducted on how to score the maps of individual learners and how to use maps in the assessment of programs.

Numerous authors discussed the development of formulas for scoring individual maps. Yao, Yang, Zhao, and Huang (2006), for example, proposed an algorithm based on scoring the propositional chains in concept maps. In this method of scoring, the relationships between groups of propositions are demonstrated. Takeya, Sasaki, Nagaoka, and Yonezawa (2004) developed a formula to compare student maps to maps of teachers. MIs (2006) proposed scoring maps based on the spatial relationships in the maps. MIs developed a formula to measure the spatial distance between concepts and hypothesized that the greater the distance between concepts the less the learner actually understood about that concept. In contrast, Ruiz-Primo (2004) proposed that to use concept maps as an individual assessment tool requires that the assessment be based on the task to be mapped, the response format required by the instructor, and the scoring system. Ruiz-Primo advocated that the degree of directedness of the maps needs to be considered in the assessment. By this she meant there was high direction in the mapping task (fill-in-the-blank maps) or low direction (maps totally constructed by learners). Finally, Khamesan and Hammond (2004) moved the understanding of scoring maps forward by proposing three levels of measuring learning effectiveness with concept maps: individual learning, whole group learning, and interaction between the group and the individual. They proposed a scoring taxonomy that differentiates which concepts were created at the individual level, from new concepts that were created at the group level. They also proposed a method to analyze which concepts were transferred or rejected between the individual and the group. This work supports efforts to understand how learning differs at the individual and group level.

Research has also been conducted on developing more qualitative assessment strategies for concept maps. For example, McPhan (2008) described a developmental assessment model that provides a means for interpreting student responses within a framework of cognitive growth. In addition, Kinchin (2008) identified three distinct patterns in concept maps (spoke, chain, and network) that indicate different thinking patterns and can help identify the difference in thinking between novice and experts. Finally, Miller and Cañas (2008) attempted to combine both a topological taxonomy along with a complementary semantic component in an attempt to develop a taxonomy for classifying and scoring concept maps.

In addition, concept maps were used to provide program assessment. In these studies, maps were used to analyze what concepts were being taught and how those concepts were being evaluated. In some articles, authors discussed how concept maps were used to align curriculum with state standards. Heinze-Fry and Ludwig (2006) used concept maps to align a public school elementary life science program within the framework from the state. They designed a template concept map to demonstrate where the local program fit with the state standards. Similarly, Carnot, Gaudet, and Hinesley (2006) used concept maps in a psychology program to prepare for an accreditation visit by linking course learning goals and program goals. In addition, the CmapTools software capability for resource files to be linked to maps is expected to be useful in this process as well.

The research results on assessment and scoring of concept maps discussed here have the potential to contribute to HRD by fostering evaluation of individual student or employee learning as well as fostering summative graduate program assessment. The assessment and scoring research demonstrates that it is possible to evaluate change in concept maps both quantitatively and qualitatively, leading to a better understanding of how learning grows and changes. However, the research on assessment and scoring of concept maps has not been developed to the point that these scoring mechanisms are easy to use. The scoring mechanisms developed to date require the researcher and/or teacher to spend considerable time, effort, and energy in the scoring process. In addition, the scoring formulas are complex enough that a great deal of training is required of researchers using the scoring systems. The variability in the way in which the scoring formulas are implemented can leave open questions of reliability and validity in the change scores reported. As such, there is a great need for this line of research to continue.

Knowledge Development

Knowledge development was the third area where concept map research was conducted. The broad category of knowledge development includes knowledge modeling, knowledge elicitation, knowledge recovery, the development of team mental models and the development of knowledge management systems. Concept maps have been used in all of these areas to significantly advance our understanding of how knowledge develops within individuals, groups, and organizations. In the areas of knowledge elicitation and knowledge recovery, Coffey, Eskridge, and Sanchez (2004) described how concept maps were used to elicit knowledge for the preservation of institutional memory in the nuclear power industry. Coffey (2006) then went on to describe techniques for the creation of concept maps with a subject matter expert and a concept map facilitator. Beuter and Pinto (2004) also provided samples of knowledge elicitation techniques that can be selected based on the type of knowledge to be elicited, the software available, the sophistication of the client, and the type of problem for which knowledge is generated. Hoffman, Feltovich, Roetzer, and Eccles (2004) reported on the development of a large knowledge model made up of more than 150 concept maps. They indicated that the process of knowledge recovery is very costly when considering the time and effort needed to create knowledge models. They suggest that organizations make knowledge capture an ongoing part of their work rather than trying to elicit and recapture knowledge at a later date. In contrast to these authors, Freeman (2004), in a study comparing three treatment groups of analysts and users working together, found that concept maps did not assist the analyst during requirements elicitation. Freeman's findings are in stark contrast to other researchers working in this area, and he suggests that additional studies need to be conducted to determine if concept mapping and requirements elicitation can be combined effectively.

Concept maps have also been incorporated into the study and development of team mental models. Evans et al. (2004) hypothesized that teams exhibiting both high levels

of expert knowledge and familiarity with teammates would perform at higher levels. Bowen and Mayer (2006) described how concept maps were used with a newly formed board of directors to create shared vision, map core values, and to develop a governance structure. Basque and Pudielko's (2004) research examined the effect of dyads developing knowledge models. They found a tendency that working at a distance in a synchronous fashion was beneficial to the development of team mental models. Keller, Tergan, and Coffey (2006) found that computer-supported collaborative learning, using the KIA-tool for concept mapping, lead to better collaboration and more efficient problem solving in groups. Johnson et al. (2006) compared four research methods for studying concept maps and the development of individual and group mental models. Their study found that various models are needed to understand the complexities of how team mental models develop.

As indicated, concept maps have been used in capturing and organizing knowledge and their use in knowledge transfer is beginning to be evaluated as well. Moon et al. (2008) investigated the transfer of knowledge using concept maps. Empirical findings indicate that concept maps were more effective than PowerPoint presentations in transferring complex ideas because of the rapidity in their creation. In addition, the maps were the preferred format for a sample of military graduate students.

Finally, concept maps have been used to develop knowledge management systems in organizations such as banking (Fourie et al., 2004), the chocolate history project at University of California–Davis (Lange & Grivetti, 2006), and to develop an understanding of consumers branding knowledge (Reesink, 2004). According to Briggs et al. (2004), concept maps can also be used to develop a library of concepts accessible to the general public. They describe the CMEX Mars indicating how concept maps were used to create a knowledge management system to describe all aspects of Mars exploration.

As the research presented at the CMC demonstrates, concept maps can assist with expanding HRD research in the areas of knowledge development, knowledge modeling, and knowledge systems, especially within a variety of organizations. The field of HRD is well positioned to conduct this type of research so that additional theories can be refined and/or developed. Especially important is research and theory development in the area of knowledge systems. Many organizations are struggling with how to retain organizational knowledge and institutional memory. As is evidenced in this review, concept maps have been used to develop these types of systems, but more work is needed in this area. For example, the knowledge that retiring individuals have could be recovered and transmitted to new employees via concept maps as part of the training process. Research could then study the effectiveness of this process. In addition, research is needed to help understand how concept maps can function in analysis of job tasks, foster institutional memory, support the development of expert knowledge, and analyze social relationships and group conflicts. This type of research has the potential to foster theory development in HRD and to help both profit and non-profit organizations function at increasingly higher levels.

Professional Development

Concept maps have also been used in numerous countries to foster the professional development of teachers. The maps have been used to help teachers understand subject matter content and to assist teachers in focusing more on student learning. Maps were also used to assist in the development of lesson plans and to foster a deeper understanding of teacher beliefs. Studies also indicated that when teachers learned to use concept maps, their teaching approaches and teaching beliefs changed. For example, Leou and Liu (2004) conducted an 8-year case study of experiences of math teachers, finding that concept maps assisted the teacher to change from the deliverer of content into the communicator and distributor. In this study, math teaching changed and effectiveness increased as the participant gained more self-confidence. Bermejo, González, and Mellado (2004) used concept maps to assist teachers in developing their understanding of the philosophy of science. Conlon and Bird (2004), in a study in Scotland, found that concept mapping is not yet part of mainstream teaching practices, but they also found that most teachers regard mapping highly as a teaching technique. They conclude that with the right kind of support and increased staff development, teachers can gain confidence to use mapping in their teaching and thus expand their teaching repertoire.

Concept maps have also been used to foster development within other professions. Barrette (2008) analyzed how IT professionals develop both theoretical knowledge and reflective practice. Study findings indicate that the maps

helped show that the contributions of theoretical and expert models can be distinct yet compatible. It [mapping] also has been effective in supporting discussion, validation and hopefully theorizing among a community of professional practitioners, simultaneously nurturing empirical knowledge and effective professional practices. (Barrette, 2008, p. 723)

As demonstrated here, concept maps have been used in professional development programs for educators. The maps have assisted these educators to refine their teaching techniques. However, research has not demonstrated that the maps are effective in the professional development of faculty in higher education programs. As such, the impact that maps have or could have on faculty in HRD graduate programs is unknown at present. In addition, concept maps have the potential to aid in career development plans of employees in business and industry, but once again research in this area is lacking.

Research Methods

Finally, use of concept maps as research tools was an area discussed by authors of the CMC papers. It is interesting to note that Iuli and Helldén (2004) reminded us that concept maps were originally developed as a data analysis tool to demonstrate how children's understanding of science grew and changed during a longitudinal study. Iuli and Helldén went on to describe four research studies in which they use concept maps as part of the methodology. They stated,

In the first, concept maps were used as a tool for analyzing interview data of students' understanding of ecological processes over a six year period. In the second, concept maps are being used to compare individual students' understandings of the transformation of matter with students' shared understandings. In the third study, concept maps were used as a research tool by a team of research scientists. They were found to help some members of the team to identify research questions that guided their individual research project. The fourth study is using concept maps to investigate the development of students' conceptual understanding of science in environmental problem solving based courses at colleges and universities across the U.S. (p. 367)

In addition, Carnot (2006) described the use of concept maps as a way to organize literature reviews for two large-scale projects. Cahuzac and Le Blanc (2004) discussed how concept maps were used during an anthropological field study to explain mental representations of participants. Daley (2004) provided examples of how concept maps were used in qualitative research to frame research projects, reduce data, analyze themes, and present findings. She went on to indicate that the advantage of using concept maps in qualitative research is linked to maintaining the meaning of the data in a unique context, but the disadvantage may be the complexity of the maps. Kozminsky, Nathan, and Kozminsky (2008) also used concept maps as a data analysis tool in qualitative research. They used maps to analyze think-aloud protocols in a grounded theory study. Finally, Okada (2008) articulated four techniques for using concept maps in developing inquiry-based research projects. Okada described how maps were used to develop a research profile that represented a personal and professional path, to design a research project, to organize key concepts from the literature, and to integrate key arguments when writing the research findings.

What this work demonstrates is that concept maps have a role to play in both quantitative and qualitative research methods in a variety of disciplines, including HRD. The maps have a role to play in organizing literature reviews, designing research studies, identifying research questions, and in analyzing data. Because the maps have been shown to facilitate thinking and analytical processes, researchers could benefit from incorporating the maps into multiple places in their research designs. What has not been demonstrated, however, in the research reviewed here is how the maps can be used to teach research methods. The field of HRD could benefit from studies designed in this area, especially graduate programs in higher education.

Implications for Practice, Research, and Theory Development in HRD

As demonstrated in this review, concept mapping research has expanded significantly with the advent of the International Concept Mapping Conferences. The CMC has provided an avenue for dissemination of concept mapping research from around the globe. Based on our review of the CMC proceedings and the themes identified in this article, we

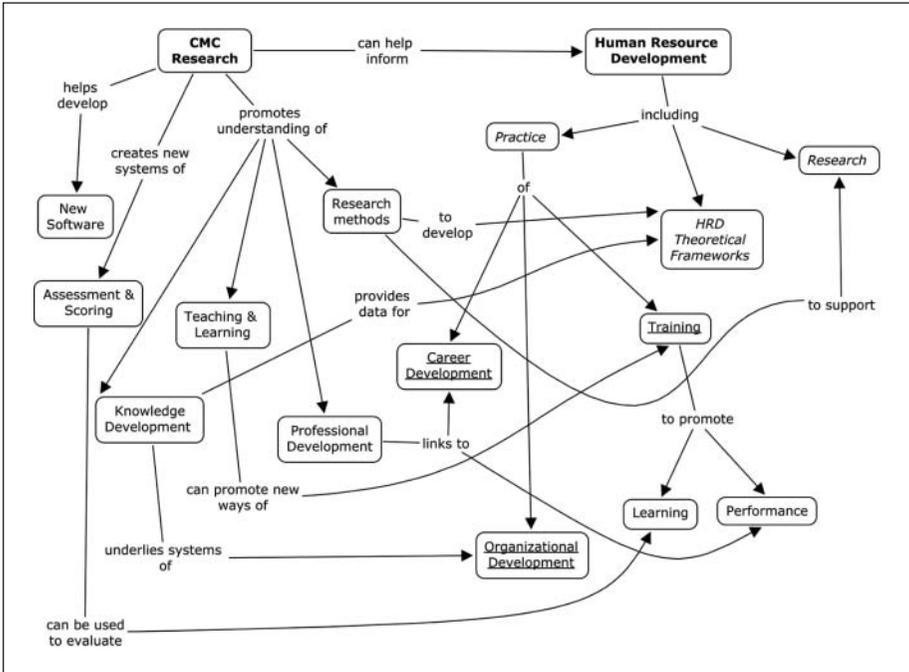


Figure 3. Connections between International Concept Mapping Conference research and human resource development

advocate that the next generation of concept mapping studies be designed to integrate the use of concept mapping into areas that have been neglected or underexplored, namely, HRD. The themes identified in this review lead us to believe that concept mapping can assist in numerous areas of practice, research, and theory development in HRD.

As a way to explicate the connections between the CMC research and HRD, the concept map in Figure 3 was developed.

As a caveat, we recognize that readers may have different perspectives or conceptualizations of HRD than we demonstrate in this map; however, the intent here is not to present an exhaustive definition of HRD theory, research, and practice but rather to present an initial framework for how concept mapping research may link with and inform HRD in these areas. As can be seen in Figure 3, we identified that HRD includes practice, theoretical frameworks, and research. Concept maps can be used to support the development of all of these areas.

Within HRD theoretical frameworks, concept mapping research in knowledge development and research methods has the potential to assist HRD researchers in developing new theories of HRD. Concept maps can function as one tool in theory development. For example, Senge, Roberts, Ross, Smith, and Kleiner (as cited in

Lynham, 2000, p. 160) define a theory as “a fundamental set of propositions about how the world works, which has been subject to repeated tests and in which we have gained some confidence.” In this view of theory development, concept maps can assist in displaying the connections between numerous concepts leading to a set of propositions to be tested. The maps form the basis for the conceptualization of theory that ultimately will need testing and further development.

Concept maps may also assist in developing theory from HRD practice, by facilitating the process of moving back and forth between deductive and inductive thinking (Lynham, 2002). For example, problems in the practice of HRD can be depicted in a concept map and that same map can then be linked to theoretical constructs. On the other hand, current HRD theoretical frameworks could be mapped and linked to issues and problems in HRD practice. Either way the incorporation of mapping in this development of theoretical frameworks has the potential to add clarity and depth to the development of HRD theoretical frameworks.

Advancing HRD research could be facilitated by using concept maps as part of the quantitative and qualitative research methods incorporated in the field. In the research studies presented at the CMC, it has been demonstrated that concept maps can be developed to depict research design, organize literature reviews, link specific research methods to research questions, and present findings. These same strategies could be applied to developing and conducting HRD research, specifically in developing research methods. For example, concept maps in HRD lend themselves to developing conceptual models for testing (Fornes et al., 2008), to analyzing interview data collected in qualitative studies (Daley, 2004), and to presenting research findings (see Figure 2).

Finally, within HRD practice, which in our view includes career development, organizational development, and training (Swanson & Holton, 2009; Watkins, 1989), concept mapping research in the areas of professional development, teaching and learning, assessment and scoring, and knowledge development could be used to enhance HRD practice. What is evident in the research from the CMC proceedings is that the incorporation of concept maps within career development, organizational development, and training has the potential to deepen and expand both the learning and performance that HRD practitioners are seeking. However, as the maps are incorporated into this area of HRD, further research will be needed that demonstrates specific outcomes and changes achieved in the process.

In conclusion, Golde (2006) indicated that scholars in a discipline should be “capable of *generating* new knowledge and defending knowledge against challenges and criticism, *conserving* the most important ideas and findings that are a legacy of past and current work, and *transforming* knowledge that has been generated and conserved by explaining and connecting it to ideas from other fields” (p. 10). Our intent in writing this literature review was to demonstrate that concept maps can serve as one tool to assist HRD researchers and scholars to generate, conserve, and transform knowledge for the purpose of developing theory, research, and practice.

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