Using concept maps to understand student learning in a compulsory volunteering subject in occupational therapy

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Abstract

Introduction: Concept maps help learners identify changes in the quality of their learning. Students in a compulsory volunteering subject were required to construct concept maps prior to the commencement and at the conclusion of a subject.

Method: Utilising two methods of analysis, cognitive structural analysis and quality of learning change, before- and after-subject concept maps of 14 students were contrasted to identify the changes in their learning from the beginning to the end of the subject. Two examples of concept maps were then selected for further description.

Results: The findings showed that there was considerable variation in the way students constructed their knowledge, and that prior knowledge was a significant influence in learning quality.

Conclusions: Concept mapping was identified as a useful teaching and learning tool for both students and academics. Students are able to monitor their evolving mastery of a topic, while academics may use concept mapping to explore expected learning outcomes.

Keywords: learning; educational measurement; professional education.

Introduction

Compulsory volunteering, or service learning, is defined as "a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student

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learning and development" (Jacoby, 1996, p. 5). The students in this study participated in 26 hours of compulsory volunteering in primary and secondary schools located near the university. The subject learning outcomes included building skills in occupational engagement and social participation, and learning by doing, each of which are core concepts in the discipline of occupational therapy (Witchger-Hansen et al., 2007).

Concept mapping is an assessment and evaluation tool used to gain an understanding of learning, specifically knowledge structures and cognitive development of subject matter (Novak & Cañas, 2008). A concept map is a graphical model comprising labels of specific ideas, termed "concepts," connected to one another via links that describe the relationships to other concepts. Two concepts connected by a linking statement in turn form "propositional statements" that reflect a statement of understanding, as perceived by the concept map author (Kinchin, Hay, & Adams, 2000; Novak, 2010). Concepts may only be used once on each map; however, they can be linked to any number of concepts via "linking statements" (Kinchin et al., 2000; Novak, 2010). An example of the key components of concept maps is shown in Figure 1.
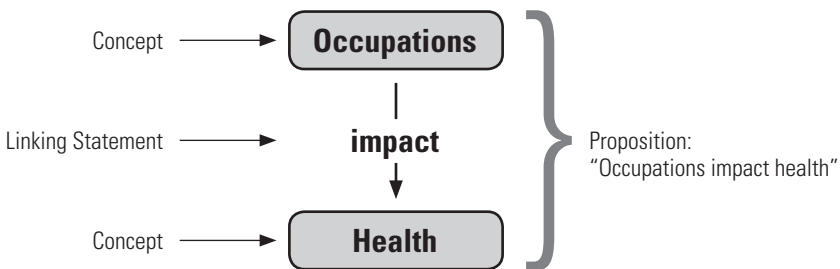

Figure 1. Components of a concept map.

Background

Concept maps have been used in education as both a method of learning and evaluation in disciplines such as physics, biology and mathematics (Kinchin et al., 2000). Researchers have argued that concept mapping is an excellent tool for outlining students' abstract and implicit knowledge, and provides an indication of how they construct, organise and represent knowledge in their minds (Hay, 2007; Hay & Kinchin, 2006; Novak, 2010). A students' concept map is claimed to unveil "cognitive structures unique to its author" (Kinchin et al., 2000, p. 44). However, more importantly, as described by Hay, Wells and Kinchin (2008), the concept mapping method is able to produce a "snapshot" of learning and can "actively differentiate between knowledge (identification of appropriate concept labels) and understanding (propositional statements)" (p. 302). Knowledge and understanding are two broad categories often used to define learning

across disciplines (Hay & Kinchin, 2006; Marton & Booth, 1997). Thus, learning quality can be measured when a student maps the same topic before and after the course of their study, and these "snapshots" are contrasted and their quality compared.

Concept maps are constructed using the student's personal understanding and tacit knowledge (Hay, 2007). Tacit knowledge is described as learning gained when there is "no intention to learn and no awareness of learning at the time it takes place" (Eraut, 2000, p. 115). It is acquired as a combination of new knowledge, experiences and emotions that remain implicit to the learner; as a result, tacit knowledge is often difficult to articulate and communicate (Eraut, 2000; Kinchin, Cabot, & Hay, 2008; Novak & Canas, 2008).

Experiential learning (that is, learning from experience) is at the core of occupational therapy practice. It is the process by which clients acquire new skills and knowledge to adapt to new situations in order to fully participate in the occupations most meaningful to them (Law, 2002). Occupational therapy's unique emphasis on enabling clients to "do" occupation(s) makes the discipline essentially experiential. Through its theoretical underpinning in experiential theory, occupational therapy places particular value on engaging students as active participants in their own learning. Students are not only applying principles of experiential learning theory to promote participation in occupations by individuals and communities but are learning experientially through active involvement in meaningful occupations to achieve the educational objectives of their course (Cashman & Seifer, 2008). This is claimed to result in learning that is "meaningful, contextual and empowering" (Witchger-Hansen et al., 2007, p. 29). The compulsory volunteering subject that is the focus of this paper demands active participation and experiential learning in students, and provides opportunities for them to reflect on this experiential process. This research aimed to explore student knowledge and understanding of experiential learning in a compulsory volunteering subject for occupational therapy students using concept maps.

Methods

Design

Student learning was explored using concept maps (Novak, 1964). Concept mapping was a hurdle requirement of the subject to assist students with writing essays. All students were provided with instructions on how to complete a concept map and given 20 minutes to complete the task. Students constructed maps in the first and final workshops of the subject. The "focus question" to guide the students' construction of the concept maps was: "How do people learn by experience?"

Participants

All participants were recruited from a cohort of occupational therapy students participating in a compulsory volunteering subject at La Trobe University (Victoria, Australia) in 2011. The students were commencing the second year of their degree. The selected cohort (n=26) commenced the 8-week compulsory volunteering subject

in February 2011 and completed their classes at the beginning of April 2011. Twenty students attended the final class of the subject when recruitment for the study took place. Students who provided consent and had completed both before-subject and after-subject concept maps were included in the study. This resulted in a sample of 14 participants, who were assigned pseudonyms. Ethics approval for the study was obtained from the La Trobe University, Faculty of Health Science ethics committee prior to commencement.

Measures

Two qualitative methods of concept map analysis, cognitive structure analysis and quality of learning change analysis, developed by Kinchin et al. (2000) and Hay (2007), respectively, were used. The concept maps following Kinchin's cognitive structure analysis were classified according to their overall structure as either spoke, chain or network. The concept map morphologies typical of these cognitive structures are presented in Figure 2.
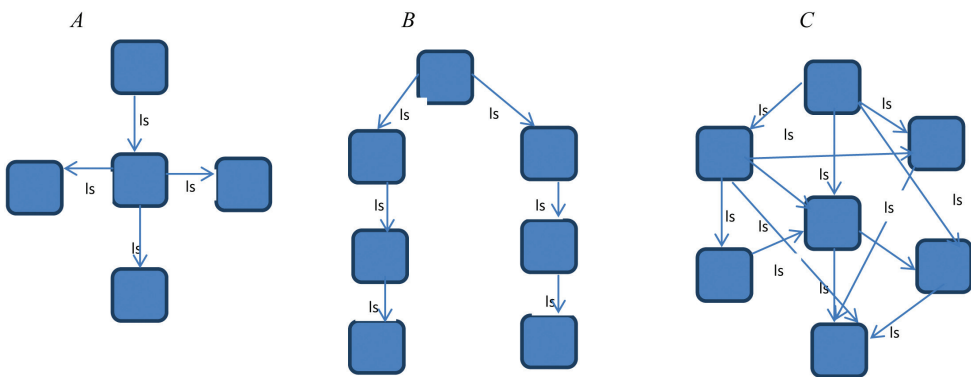

Figure 2. Examples of concept map gross morphologies.
A spoke, B chain, C network
Legend: ls = linking statements

Typically, spoke structures (A) are the most basic of the three cognitive structures, consisting of a one-level hierarchy with simple associations (usually centred on one concept). A chain cognitive structure (B) incorporates a multi-level hierarchy, but concepts are often constructed using a "temporal sequence." Finally, network structures (C) are described as demonstrating the most complex and interactive relationships, where each concept is likely to be linked to other concepts at many levels, thus showing a high integration of ideas (Kinchin et al., 2000).

The concept maps were also evaluated for structural development. For example, while an after-subject concept map may not have a changed structure, it may show more developed thinking or integration of new knowledge. Additionally, structural change

was indicated when the before- and after-subject concept maps were constructed using different cognitive structures (that is, if a student constructed their before-subject concept map using a chain structure, but their after-subject concept map using a network structure).

When using Hay's quality of learning change analysis to measure the quality of learning change in each student, the before- and after-subject concept maps were contrasted and classified as indicative of either meaningful learning, rote learning or non-learning. These categories were based on the work of Novak (1998) and Jarvis (1993), who described non-learning, rote learning and meaningful learning as follows. Non-learning was indicated when the after-subject concept map predominantly contained similar concepts, which were repeated from the before-subject concept map. This indicated that little change in learning had occurred. Rote learning was indicated when the after-subject concept map contained new (or deleted) concepts when compared to the before-subject concept map, indicating a change in learning, which, however, was often poorly integrated with the retained knowledge. Meaningful learning was signified when the after-subject concept map showed comprehensive integration of new knowledge (added concepts) with prior knowledge (retained concepts from the before-subject concept map), specifying that a broader understanding of the subject was achieved.

Table 1

Criteria for Analysing Quality of Learning Change in Concept Maps (Hay, 2007)

Learning outcome	Non-learning	Rote learning	Meaningful learning
Comparison between pre- and post-subject concept maps shows:			
Prior knowledge remains	✓	✓	✓
Reorganisation is present	✗	✗	✓
New concepts are added	✗	✓	✓
New links are developed	✗	✗	✓
New propositions reflected added meaning	✗	✗	✓

Strategies to enhance quality and trustworthiness

Three researchers contributed to the analysis of concept maps to ensure that each map was comprehensively explored. Additionally, examples of concept maps are presented in the paper to confirm the authenticity of the findings and to strengthen the readers' confidence in the interpretations made.

Results

Cognitive structure analysis of the concept maps (Kinchin et al., 2000) showed that students' knowledge structures remained largely unchanged. Almost all, however, exhibited structural development, whereby their second concept maps were either more elaborate or detailed than the first (see Table 2).

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Table 2
Findings from 'Cognitive Structure' Analysis of All Students' Before- and After-Subject Concept Maps.

Student	Before-subject concept map (Map 1)	After-subject concept map (Map 2)
Amy	Chain	Chain
Anna	Network	Network
Claire	Network	Network
Jess	Network	Network
Jill	Spoke	Spoke
Kate	Chain	Network
Kim	Chain	Chain
Laura	Chain	Network
Mark	Spoke	Spoke
Mary	Spoke	Spoke
Sarah	Chain	Chain
Tim	Chain	Chain
Tom	Chain	Chain
Vicky	Network	Network

In relation to quality of learning changes, two students' concept maps (Anna's and Vicky's) fulfilled the full criteria for meaningful learning. Both students constructed their maps using network structures. Their after-subject concept maps showed thorough integration of the subject's core concepts with their prior knowledge, indicating a deep understanding of the subject matter.

Five students' concept maps portrayed changes indicative of a mixture between meaningful and rote learning. These students were able to integrate newly-learnt concepts in their after-subject concept maps; however, these were either inadequately integrated with their prior knowledge (concepts from the before-subject concept map), inadequately linked to other concepts on the map in a way that was meaningful, and/or did not increase the overall meaning or "explanatory power" of the map.

Four students demonstrated changes in learning quality indicative of a mixture between rote and non-learning. Although these students included new concepts in their after-subject maps, they either persisted in including concepts from their before-subject concept maps that were seen to be outside the scope of the subject matter or were not able to link these concepts to one another to portray adequate understanding of the subject.

Only one student (Tim) fulfilled the criteria for non-learning. He showed little change in structure or conceptual links in his before- and after-subject concept maps.

In order to illustrate the variation in student learning, the concept maps of Vicky and Tim are further described. The paired concept maps were colour-coded (to show evidence of analysis) using the CmapTools computer program. CmapTools was specifically developed for the construction of concept maps (Novak & Canas, 2008).

An example of meaningful learning

Vicky's before and after concept maps were classified as network structures because access to any particular concept could be achieved via several routes. Vicky's before-subject concept map consisted of 10 concepts, and her after-subject concept map comprised 13 concepts. Although this was a small change in the number of concepts, the number of conceptual links in her second map was dramatically higher at 29, compared to 19 on her first map.

Vicky retained a total of five concepts from her first concept map in her second. These were "learning," "knowledge," "skills," "practice," "hands on." She arranged them in almost corresponding positions in the first and second maps. Although the concept labelled "people" was rejected from her first concept map, it persisted in her second map as a linking word between the newly integrated concepts "abilities," "observing," "behaviour" and "attitudes." By using the concept as a link, she was able to add meaning to her map, and demonstrated her awareness of the multidimensional and individual nature of the process, by which different people learn by experience. Moreover, her after-subject concept map included "culture" as a core concept influencing "attitude" and "behaviour," indicating her understanding of learning as an individual process. Other newly added concepts included "reflection," "mistakes" and "identify issues," which she appropriately linked to "knowledge," showing her more developed understanding of the subject matter. Only four concepts were rejected from the first map to the second. These were "technique," "reality," "theory" and "new environments."

When compared, Vicky's first and second map also showed the strongest example of quality of change, indicative of meaningful learning in the cohort. Her first map demonstrated that Vicky entered the subject with strong prior knowledge of experiential learning. This was evidenced by her comprehensive awareness and organisation of core concepts such as "practice," "hands on," "theory," "knowledge," "new environments" and "people" and her ability to link these concepts to one another to enhance the overall meaning of her map. The second map that she completed after the subject demonstrated that she had considerably advanced her understanding of the focus question. The structural organisation, linkage and explanatory power of her second map was superior to her first. She was not only able to include important new concepts in her second map but was able to adequately link these to one another as well as to the retained concepts of her prior knowledge. Further, she demonstrated increased understanding of the retained concepts on her map as portrayed by the greater numbers of conceptual links between them. The quality of change from Vicky's first map to her second indicated an improved quality of change in her learning, as she was able to re-conceptualise and reorganise her ideas to reflect new and personal learning from before and after the course.
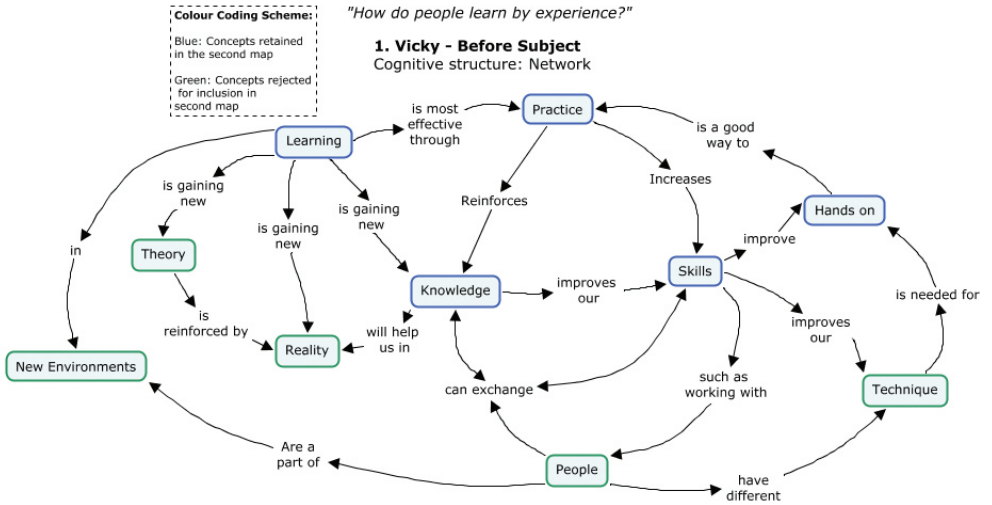
USING CONCEPT MAPS

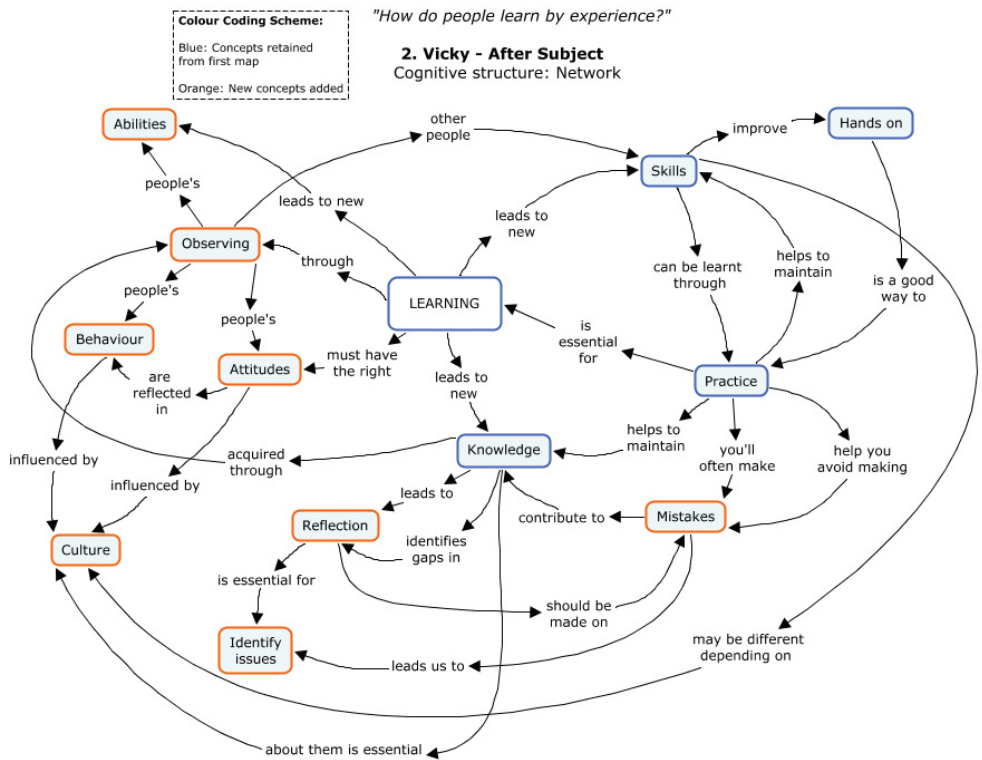*Figure 3.* Vicky's before-subject concept map.

Figure 4. Vicky's after-subject concept map.

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An example of non-learning

The changes in the quality of Tim's concept maps from before to after the subject showed the greatest degree of non-learning in the cohort. Both his maps were constructed using organisationally almost-matching chain structures and were limited in structural development. They each consisted of 12 links. Although his post-subject concept map consisted of 14 concepts compared to his original 12, two concepts ("positive" and "negative") were used twice on the same map, an infringement of the rules of concept mapping developed by Novak (2010).

Tim's concept map constructed before the subject suggested he had little prior knowledge to be able to answer the focus question. The use of concepts such as "positive (rewards)," "negative (punishment)," "repeat actions" and "avoid actions" indicated that he was able to draw on his understanding of operant conditioning to describe how people learn by experience. The map he completed after the subject did not indicate significant change in this prior knowledge or understanding. Eleven of the 12 concepts in his first map were retained in the second. Some were represented using alternative labels. For example, the concepts "friends," "family" and "individual" on the first map were represented under "peers," "parents" and "teachers" on the second map. The concept of "an individual's common sense" was retained and used as a linking word between "we learn by experience" and "logical response." There were only two newly
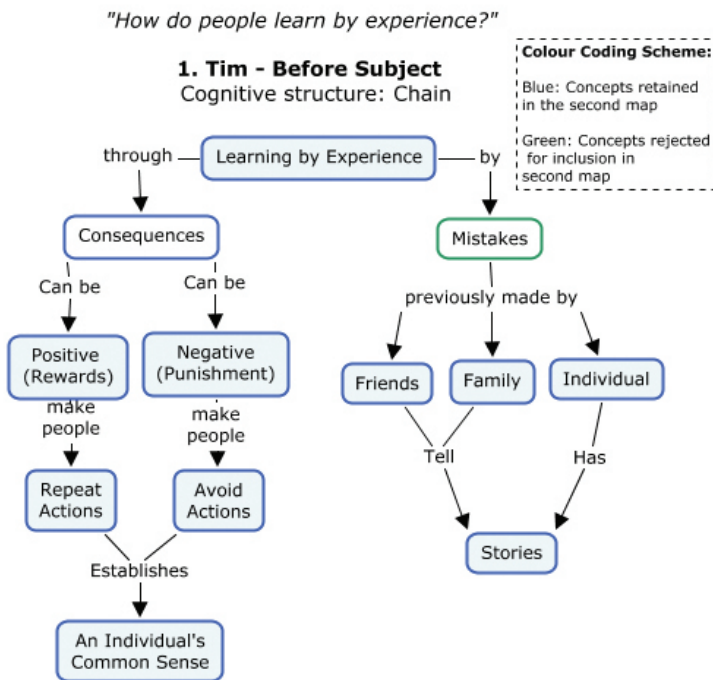

Figure 5. Tim's before-subject concept map.
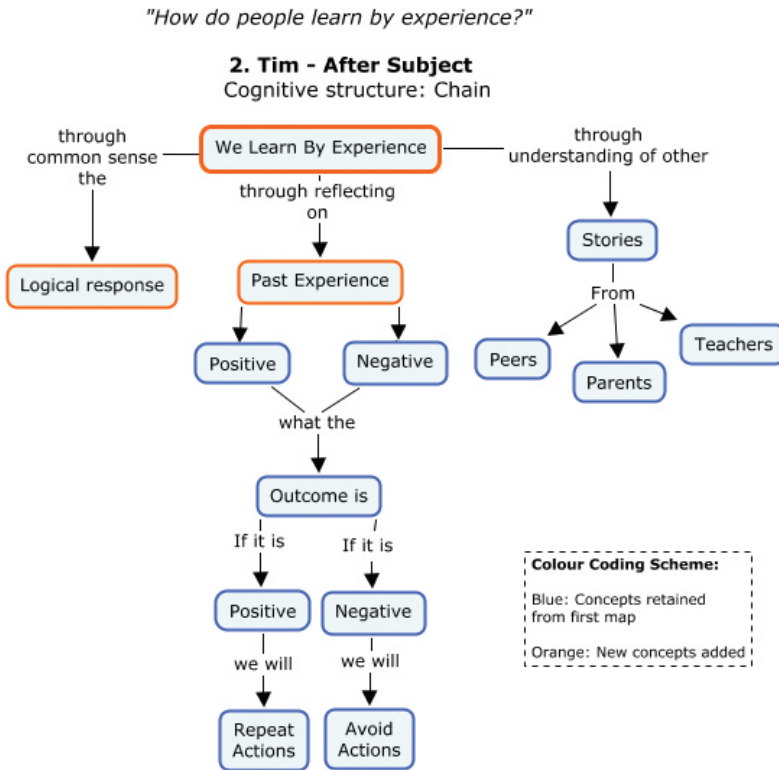
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Figure 6. Tim's after-subject concept map.

introduced concepts in the second map ("logical response" and "past experience"), and while his proposition of "we learn by experience through reflecting on past experience" was indicative of the subject matter, the concept of the "logical response" did little to enhance the explanatory power of the map in answering the focus question.

While there was evidence of minor reorganisation of concepts between the first and second map (such as seen between "stories"' and "peers," "parents" and "teachers"), the absence of newly developed links and the limited addition of new concepts indicated that Tim was unable to modify his static prior knowledge and understanding of the focus question. The second map did not explain the focus question any better than or differently from the first and was thus seen as indicative of non-learning.

Discussion

The findings revealed considerable variation in understanding of the concept of experiential learning in a cohort of students undertaking a compulsory volunteering subject. The compulsory volunteering subject provides a rich context for learning; however, student engagement with the unpredictable experiences they encounter in

this setting does not automatically translate into meaningful learning. Reflections on their experiences need to be structured, and frequent connections to identified learning objectives made explicit, in order to develop more meaningful learning around key concepts. Each student came to the subject from a different starting point and constructed a unique understanding of the focus question: "How do people learn by experience?"

Only two students were able to satisfy the criteria for meaningful learning. Significantly, the differences in breadth of prior knowledge impacted the students' quality of integration of newly acquired knowledge, evident in their second map. It appeared that students who demonstrated an in-depth prior knowledge of core concepts related to the focus question in their first concept map were able to acquire new knowledge (through the addition of relevant concepts) and better integrate this in their second map. The implication is significant. If at the beginning of a topic the educator understands what the students already know, they can use this as a scaffold for acquiring new information (Hay, Kinchin, & Lygo-Baker, 2008; Novak & Canas, 2008). Without an understanding of students' knowledge starting points, educators can only guess that they are pitching learning experiences at the right level. If we aspire to achieve transformational learning experiences (Mezirow, 2000) rather than an accumulation of knowledge, understanding variation in knowledge starting points is critical.

With calls for widening the participation of students undertaking higher education, there has been increasing recognition of variations in student learning needs. This variation demands changes to learning and teaching approaches, assessment and the support of students (Jones & Lau, 2010). It is important that educators use techniques that facilitate some understanding of the range of prior knowledge and that they support learning approaches accommodating a diverse range of learners.

Vanhear (2013) has argued that the act of constructing a concept map requires a metacognitive process that "entails mulling, connecting, rehearsing, expressing, assessing, reflecting, revising and learning" (p. 192). While the findings of our research did not indicate this to be the case for all students, the authors believe there is potential for more active use of concept mapping within the classroom as a means of generating discussion and facilitating the desired active processes of mulling, connecting and reflecting. Students could be encouraged to share and discuss personally constructed maps or generate whole-class maps as a way of drawing on the conceptual depth of "more capable peers" (Vygotsky, 1978), including the educator, to deepen the learning experience.

Further, the use of concept maps in the classroom can support educators in monitoring and correcting knowledge misconceptions, along with the identification of students at risk of resorting to superficial learning. Educators, too, might consider creating their own concept maps to share their expertise with students (Kinchin, Baysan, & Cabot, 2008), a method that makes the expertise of educators transparent and "available for scrutiny by students" (Kinchin, Cabot, & Hay, 2008). Educators may lack awareness of the tacit knowledge they possess (Polanyi, 1966) that underpins their understanding of more complex concepts and may therefore fail to convey the underlying knowledge that

facilitates students in making conceptual leaps. The use of concept maps to illustrate key ideas, or to track the development of ideas over the course of a subject, can make this expert knowledge visible and available to students (Hay, Kinchin, & Lygo-Baker, 2008). The potential use of concept maps in different learning contexts is illustrated in some examples by Kinchin, De-Leij and Hay (2005), Chiou (2008), Wang, Wu, Chen, Kinshuk and Spector (2013) and Vanhear (2013).

Limitations of the study

Concept maps were constructed by students in response to one focus question relating to experiential learning, which related to one of several learning outcomes of the compulsory volunteering subject. Although some students showed little learning change through their concept maps, this is not to say that learning or developmental change did not occur in other areas of their knowledge, values, and personal and interpersonal skills and abilities.

Secondly, although concept maps are regarded as effective tools in revealing a mapper's thought structures, personal knowledge and understanding may at times remain hidden (Hay & Kinchin, 2006). Students were required to construct their maps within a 20-minute time limit and, further, their after-subject concept maps were collected towards the end of the final class, held late in the afternoon following students' final presentations, a time when motivation for the construction of detailed maps may have been less than optimal. Kinchin (2013) has recently cautioned against reliance on the scoring of concept maps as a clear indicator of learning, arguing that students may be wrestling with disciplinary language (the terms used may be less clear to the map reader than to the student), or despite the inclusion of relevant concepts that strengthen their score, students may have over- or understated the importance of these concepts (Kinchin, 2013).

Finally, students were only given information on how to make concept maps at the beginning of the subject. This may have led some students to forget the basic rules of concept map construction by the end. Additionally, some students may have produced more elaborate maps not because of greater knowledge and understanding, but rather because they had become more confident with the method (Hay, Wells, & Kinchin, 2008).

Conclusion

This study explored the variability in student learning in an occupational therapy compulsory volunteering subject by using students' concept maps as a tool to examine how they constructed their knowledge and understanding of experiential leaning. Concept maps proved an effective tool in making visible the learning changes experienced by students throughout the subject. Contrasting each student's before- and after-subject concept maps using the "cognitive structure" and "quality of learning change" approaches enabled comparisons to be made to baseline measurements of prior knowledge. This, in turn, highlighted the quality of change of learning for every student. More importantly, it emphasised the variation among these students, from

those who were able to achieve meaningful learning to those who seemed to achieve little change in their knowledge and understanding relating to the focus question. The findings brought to light the need for teachers to be informed by this variation and the influence of prior knowledge in affecting future knowledge acquisition.

Concept maps have the potential to explicate both teachers' and students' tacit knowledge and enhance communication and transfer of knowledge and understanding between them. Concept maps are valuable for educators as a tool for formative assessment to monitor students' prior knowledge or learning progress and as a teaching tool to promote meaningful learning.

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