Using concept maps to optimize the composition of collaborative student groups: a pilot study

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Aim. The aim of this paper is to stimulate interest in the practical classroom application of concept mapping strategies as an approach that teachers can easily use to enhance collaborative learning.

Background. Concept mapping has been developed as a tool to support meaningful learning. However, much of the research literature fails to explain how concept maps might be most gainfully employed within the classroom. As a result, concept mapping is a tool that is under-used.

Methods. Students on a postgraduate teacher preparation programme for nurses were arranged in triads on the basis of the morphology of individually-produced concept maps for the topics of 'genetics' and 'pathogenic microbes'. They were arranged in heterogeneous triads to produce a consensus map for 'pathogenic microbes', and then in homogeneous triads to produce a consensus map for 'genetics'. The number of acceptable propositions found in their individual maps was compared with the number found in the consensus group maps, and gain scores were calculated for each participant.

Findings. Participants arranged in triads of individuals having very different knowledge structures were found to make a greater improvement than those arranged in triads composed of individuals with qualitatively similar knowledge structures.

Conclusions. The study was undertaken with a very small sample and only looked at two topic areas. However, the findings support the idea that collaborative groups work most effectively when individuals within the group bring different perspectives to a problem, and that this perspective can be usefully identified within the classroom environment as variations in concept map morphology.

Keywords: collaboration, education, meaningful learning, student diversity

Introduction

Concept mapping has been developed, with emphasis on its use in science teaching (Novak 1996, 1998), to promote the interaction of new material with existing cognitive structures. This is described as 'meaningful learning'. There is considerable evidence that concept mapping is a valuable teaching and learning tool. In a meta-analysis of 19 quantitative studies, Horton *et al.* (1993) showed that concept mapping generally had a positive effect on both student attainment and attitudes, while supporting a shift from rote to meaningful learning. The value of concept mapping as a tool in nursing education has been explored in a number of studies, and descriptions given of the benefits that it can bring to the students in terms of quality of learning (Irvine 1995, All & Havens 1997, Schuster 2002, Wheeler & Collins 2003, Akinsanya & Williams 2004). Increased recognition of the value of such tools reflects the shift from behavioural to cognitive perspectives on learning (Cust 1995).

Teaching science topics

In their review of nurses' understanding of physical sciences, Wilkes and Batts (1998, p. 131) concluded that nurse educators must 'provide openings for discussion…in the nursing context and give the students ample time to explore their own ideas'. This, they suggest, should be achieved by developing 'successful teaching strategies whereby the influence of image, shared experiences and shared language will, through reflective practice, be used to the advantage of their students' (Wilkes & Batts 1998, pp. 131–132). Collaborative concept mapping may be able to address these issues. It has also been suggested that the promotion of meaningful learning by concept mapping can reduce subject-based anxiety (Jegede *et al.* 1990). This may be an additional benefit in nurse education, in which the study of biology seems to cause stress in some students (Nicoll & Butler 1996).

Collaborative learning

Okada and Simon (1997) showed that students are more likely to entertain various hypotheses and explore different ideas when working in groups. It seems likely that the variety of ideas held within a group could be maximized if its members were chosen on the basis of differences in their knowledge structures (Wood & O'Malley 1996). This is different from arranging groups by perceived ability. Knowledge structures are as much the result of experience as of ability, and so an individual student's level of expertise will vary from one topic to the next, depending on of their relevant prior experiences.

Within such a model, a variation in size of effect is anticipated, resulting from variation in the degree to which the generated cognitive conflict was expressed or acted out to activate differences in students' points of view. In describing prerequisites for cognitive restructuring, Perret-Clermont (1980, p. 118) uses 'minimal competence' to describe a threshold level over which a student must climb in order to benefit from social interaction:

> Social interaction can stimulate constructive activity only in so far as the subject has attained a level of competence sufficient to benefit from that interaction.

This minimal competence includes prerequisites for both social interaction and cognitive restructuring. A more holistic view is taken by Glachan and Light (1982, p. 258), who consider the outcome of an interaction to be equal to more than the sum of the parts contributed by individual students:

> It would appear that interaction between inferior strategies can lead to superior strategies or, in other words, two wrongs can make a right.

Concept maps

Kinchin *et al.* (2000) have proposed a qualitative classification of concept map structure in which three basic map structures are recognized, and are described as spokes, chains and nets. The main characteristics of these structural types are summarized in Figure 1.

The map types represent different stages in the development of an expert view. Exemplars for the topic 'pathogenic microbes' are given in Figure 2. The 'spoke' structure provides the most flexible foundation from which a student can construct further understanding. It permits additions and deletions from the basic framework without the requirement for radical restructuring of the whole map. The 'chain' is seen as an unfortunate consequence of a typical teaching approach in which lectures are perceived by students as occurring in unrelated sequences. In addition, the 'chain-type' map is particularly problematic when students are required to restructure their understanding in the light of new information. The 'net' is seen as characteristic of an expert perspective. The degree of cross-linking within the map confers a degree of stability, whilst also allowing various routes through the map (necessary when viewing an issue from an alternative perspective). Restructuring to develop a 'net-type' framework often requires the selection of a more appropriate organizing concept at the top of the map (Figure 2c). This often gives a better overview of the topic, and allows for the more effective systematic arrangement of subordinate concepts.

The study

Aim

The aim of the study was to test the model proposed by Kinchin *et al.* (2000) to see if differences in the morphology

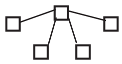
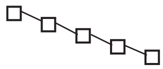
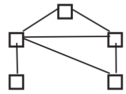
Structure	SPOKE 	CHAIN 	NET 
Hierarchy	Single level	Many levels, but often inappropriate	Several justifiable levels
Additions	Additions to central concept do not interfere with associated concepts	Cannot cope with additions near the beginning of the sequence	Additions/deletions may have varying influence as 'other routes' are often available through the map
Deletions	Have no effect on overall structure	Disrupt the sequence below the deletion	
Links	Often simple	Often 'compound', only making sense when viewed in the context of the previous link	Often employ technical terminology to enhance meaning

Figure 1 Characteristics of spoke, chain and net-type concept maps.

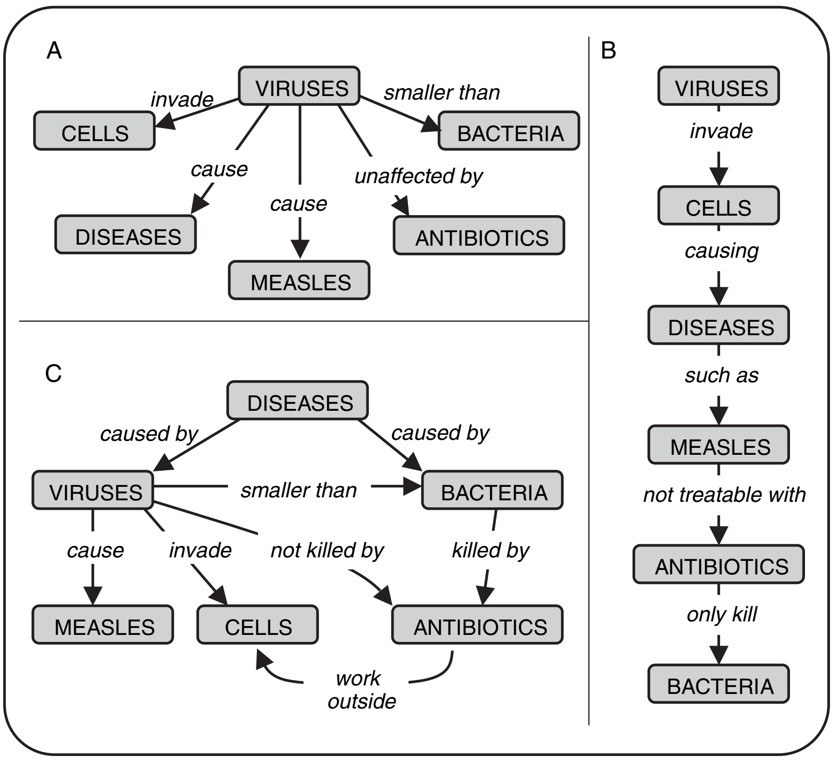


Figure 2 Exemplar concept map fragments of six concepts associated with pathogenic microbes. A, spoke; B, chain; C, net.

of student concept maps could be exploited as a tool for non-judgemental differentiation of knowledge structures. This should enable the purposeful manipulation of group composition to maximize learning.

Design

A pilot study with a convenience sample was carried out in April 2000.

Participants

The potential of this concept mapping for optimizing group structure was investigated as a classroom intervention with all 12 postgraduate trainee teachers enrolled on a part-time postgraduate certificate in the education of adults (PGCEA) programme. The participants were all studying to be nurse teachers and had a grounding in biological science. Although concept mapping has been promoted in the literature as a useful learning tool for nursing (Irvine 1995, All & Havens 1997), none of the participants claimed familiarity with it. The topics used as vehicles for the tests were ‘pathogenic microbes’ and ‘genetics’ – topics with which all the participants should have been familiar at a basic level.

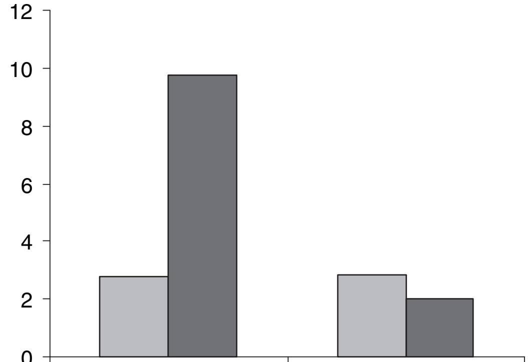
Data collection

Initial training in the use of concept maps was provided in the form of a 2-hour taught session. A pilot study was then run in two stages.

Stage 1

Participants were given a list of 20 basic concepts associated with pathogenic microbes. The list was checked against a number of nursing texts to ensure suitability. Participants were asked to construct concept maps individually (without reference to colleagues or to other materials). These maps were quickly assessed (the entire process taking about 5 minutes) and categorized as a ‘spoke’ a ‘chain’ or a ‘net’ type map. The quality or appropriateness of individual links or concepts was not evaluated at this time.

Maps were then sorted into groups of three, each group consisting of one ‘spoke-dominated’, one ‘chain-dominated’ and one ‘net-dominated’ map. Each triad of students was then asked to compare their individually-produced maps and produce a ‘consensus map’ from the group. These group maps and the individual maps from which they were derived were all evaluated and the number of acceptable propositions included in each was recorded. A gain score (from individual map to group map) was calculated for each participant.



	microbes	genetics
individual	2.75	2.83
group	9.75	2

Figure 3 Average gain scores for individually- and collaboratively-produced maps for the topics of ‘microbes’ and ‘genetics’.

Stage 2

This was similar to stage one, but used the topic of genetics. This time groups were arranged so that participants who had produced similar maps were put together in triads (e.g. all ‘spoke-dominated’ or all ‘chain-dominated’ maps). Gain scores were again calculated for each participant. A comparison of the average individual and group scores for the microbes (heterogeneous/mixed groups) and genetics trials (homogeneous/similar groups) is shown in Figure 3.

Ethical considerations

Approval to undertake this study was obtained from the course coordinator and from the participants. No participants are identified by name or affiliation, and they were assured of anonymity in published reports.

Results

The difference in average gain scores between the two groups was pronounced: +7 for the heterogeneous groups (microbes) and $-0{\cdot}825$ for the homogeneous groups (genetics). The scores achieved by the heterogeneous groups were greater than the sum of the scores gained by the individuals. This reinforces Glachan and Light’s claim that ‘two wrongs can make a right’ (Glachan & Light 1982, p. 258). It is possible that ‘wrong’ elements from an individual’s map simply needed to be re-contextualized in order for them to become ‘correct’. A sharing of perspectives in the collaborative groups may have facilitated such a re-contextualization. It would be possible to account for the difference in gain scores if the group found genetics a more difficult topic than microbes. However, the

What is already known about this topic

- Concept mapping helps students to reflect on their prior knowledge.
- Concept mapping promotes meaningful learning among students.
- Concept maps provide a visual representation of the structure of a knowledge framework held by a student.

What this paper adds

- A classroom tool that may help teachers to consider the composition of collaborative student groups.
- A simple classification of concept maps can be used to enhance collaborative learning.
- Student diversity can contribute positively to classroom learning experiences.

starting values (number of acceptable propositions within individual maps) were similar for each topic (the genetics base score was actually slightly higher).

Discussion

With the small sample size used in this pilot study, it would be dangerous to make generalizations. Whilst there was an indication that groups may be stimulated by promoting variations within group structure, the nature of this stimulation and its effect on individual learning may vary considerably from one student to another.

Future research should investigate how student interactions inform the development of knowledge structures – this may be different for students starting with spoke-, chain- or net-type concept maps. The relative importance of the three contributing knowledge structures needs to be examined. It is tempting to suggest that the spoke-type map provides a starting point upon which the group may build a more complex framework by selecting items from the chain-type and net-type maps. However, concept map morphology is only one variable that collaborators bring to the group discussion. Factors such as strength of personality and academic ability (perceived or real) may well influence individual contributions to the group consensus. The production of concept maps does help quieter students to make a contribution equal to those of more forceful peers, at least at the outset of the discussion, and so may help to produce a more balanced group outcome.

Our findings suggest that arranging student groups to maximize the variation in the gross structure of concept maps represented within the group does promote more effective exchange of information during collaborative episodes. This supports a *sociocultural* view of learning, in which interaction with others is a critical component of the process of knowledge construction. The concept maps enable each student to make their understandings explicit to the rest of the group (e.g. Akinsanya & Williams 2004) and this provides a focus for meaningful discussion. Learning outcomes from collaborative concept mapping activities have been found to be related to the quality and quantity of student interaction (e.g. van Boxtel *et al.* 2002). Organizing groups on the basis of concept map morphology may be a means to stimulate such interaction.

The study supports the hypothesis put forward by Kinchin *et al.* (2000) that variation in concept map morphology indicate different knowledge structures, and that this may be exploited to optimize collaborative group structure. The classroom classification of concept maps in this way is not an 'exact science', but nor does it need to be. The purpose of the classification is to enable the quick, qualitative differentiation of students' maps to provide a mechanism that justifies group composition for collaborative study. Many maps can be expected to depict hybrids of the three groups illustrated in Figure 1 (Kinchin *et al.* 2000). Some of the maps produced by participants in this study included two or more chains, whilst other spoke-type maps included cross-linkages between two subordinate concepts. Whether these are characterized as 'spokey-chains' or 'netty-spokes' really does not matter. What is important that teachers are able to identify students who possess structurally different knowledge frameworks so that members of a collaborative group are able to bring different perspectives to their discussion of a topic.

Conclusion

Use of concept maps could form the rationale for the composition of student groups during collaborative episodes. The purpose of group work is often to allow students to share and challenge each others' ideas, and this is most likely to occur if members bring different perspectives to their deliberations. If this can be achieved in the classroom by the rapid, non-judgemental comparison of concept map morphology, it may provide a powerful tool to support classroom practice.

Author contributions

IMK was responsible for the study conception and design, data analysis and drafting of the manuscript. DBH supervised. IMK and DBH were responsible for the data collection and critical revisions of the manuscript for important intellectual content.

References

Akinsanya C. & Williams M. (2004) Concept mapping for meaningful learning. *Nurse Education Today* **24**, 41–46.

All A.C. & Havens R.L. (1997) Cognitive/concept mapping: a teaching strategy for nursing. *Journal of Advanced Nursing* **25**, 1210–1219.

van Boxtel C., van der Linden J. & Roelofs E. (2002). Collaborative concept-mapping: Provoking and supporting meaningful discourse. *Theory Into Practice* **41**, 40–46.

Cust J. (1995) Recent cognitive perspectives on learning – implications for nurse education. *Nurse Education Today* **15**, 280–290.

Glachan M. & Light P. (1982) Peer interaction and learning: can two wrongs make a right? In *Social Cognition: Studies of the Development of Understanding* (Butterworth G. and Light P., eds), Harvester Press, Brighton, Sussex, pp. 238–262.

Horton P., McConney A.A., Gallo M., Woods A.L., Senn G.J. & Hamelin D. (1993) An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education* **77**, 95–111.

Irvine L.M.C. (1995) Can concept mapping be used to promote meaningful learning in nurse education? *Journal of Advanced Nursing* **21**, 1175–1179.

Jegede O.J., Alaiyemola F.F. & Okebukola P.A.O. (1990) The effect of concept mapping on students' anxiety and achievement in biology. *Journal of Research in Science Teaching* **27**(10), 951–960.

Kinchin I.M., Hay D.B. & Adams A. (2000) How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development. *Educational Research* **42**(1), 43–57.

Nicoll L. & Butler M. (1996) The study of Biology as a cause of anxiety in student nurses undertaking the common foundation programme. *Journal of Advanced Nursing* **24**, 615–624.

Novak J.D. (1996) Concept mapping: a tool for improving science teaching and learning. In *Improving Teaching and Learning in Science and Mathematics* (Treagust D.F., Duit R. and Fraser B.J., eds), Teachers College Press, London, pp. 32–43.

Novak J.D. (1998) *Learning, Creating and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations*. Lawrence Erlbaum Associates, Hillsdale, NJ.

Okada T. & Simon H.A. (1997) Collaborative discovery in a scientific domain. *Cognitive Science* **21**(2), 109–146.

Perret-Clermont A.-N. (1980) *Social Interaction and Cognitive Development* [translated by Carol Sherrard]. Academic Press, London.

Schuster P.M. (2002) *Concept Mapping: A Critical-Thinking Approach to Care Planning*. F.A.Davis, Philadelphia, PA.

Wheeler L.A. & Collins K.R. (2003) The influence of concept mapping on critical thinking in baccalaureate nursing students. *Journal of Professional Nursing* **19**(6), 339–346.

Wilkes L.M. & Batts J.E. (1998) Nurses' understanding of physical science in nursing practice. *Nurse Education Today* **18**, 125–132.

Wood D. & O'Malley C. (1996) Collaborative learning between peers: an overview. *Educational Psychology in Practice* **11**(4), 4–9.