Generative Learning and assessment Strategies: An Investigation into Concept-mapping

S.M. Brüssow
A.C. Wilkinson

OVERVIEW

Various studies have shown the advantages of concept-mapping in both teaching, learning and assessment practices in higher education. This case study presents findings of an investigation into concept-mapping as an assessment tool and a generative learning strategy. The significance of the case study lies in the potential of concept maps to reinforce the principle of assessment for learning. The case study commences with a description of the structure of learning; the concept of concept-mapping; the role of concept-mapping in teaching, learning and assessment with specific reference to constructivism, meaningful learning, collaborative learning and conceptual change. Subsequently the experimental design based on a two-cycle action research process is outlined which involves both quantitative and qualitative investigation techniques in the form of achieving scores and a questionnaire survey. The effectiveness of different concept-mapping tasks was contrasted with regard to achievement scores. The quantitative and descriptive findings showed that concept-mapping contributed not only to achieving efficacy, but also to conceptual development, while the majority of the learners positively acknowledged the use thereof. The findings of this investigation confirm works by others that indicate that the use of concept-mapping as a generative learning and assessment strategy can lead to achievement gain and reinforce the principle of assessment for learning.

INFORMATION ABOUT THE CLASS, MODULE OR PROGRAMME

The target group, a convenience sample, included 33 and 27 third-year learners from the programme Diagnostic Radiography at the Central University of Technology, South Africa in the module Radiographic Management III (RAB 30 at) in 2005 and 2006 respectively.

DESCRIPTION OF THE CASE

The investigation was conducted over two years with successive groups of students. The action research process consisted of two phases, described here as cycle one and cycle two. Cycle one was seen as exploratory in nature in which the data gathered influenced the approach for cycle two. The study design, a quantitative experimental study with descriptive components, was twofold. First, the efficacy of concept-mapping was determined, based on a quantitative investigation (test and exam scores). Second, a qualitative survey (questionnaire) which established learners' perceptions on the usefulness of concept-mapping was utilised.

Procedure and interventions

All learners participating in the investigation completed the following management learning units: Performance Evaluation, Management Decisions: Understanding and Coping with Them, Understanding Motivation, and Introduction to Stress. These were the learning units in which concept-mapping was put to the test and the learning content was obtained from the prescribed source (Drafke 2002, 95-139). Prior to this experience, the learners had been exposed to forms of formal instruction and interactive instructional methods during their first and second years as learner radiographers.

Formal lecture

The first learning area, "Performance Evaluation", was presented in the traditional lecture format by the researcher. The theme was covered in a one-and-a-half hour session. The lecture content obtained from Drafke (2002,95-107) was introduced by means of ©*PowerPoint* slides, which contained keywords of important facts. The learners were passive observers and no interaction was pursued. The learners were expected to memorise the content and to prepare for a formative assessment.

Concept-mapping task

In the second learning area, "Decisions", the learners were asked to draw a concept map using a list of terms taken from the chapter of "Managing Decisions" from the prescribed source. Learners could not be told of the details of a scoring scheme or the assessment criteria in advance, because the scoring system was only developed as the research progressed. The first maps were returned to the class. The feedback on the initial maps was of a qualitative nature, while examples of a range of learner maps were shown, and some particular faults and good features pointed out. Both good examples and those that demonstrated some misconceptions were displayed (without identification), as a basis for a class discussion. This was a valuable classroom exercise. The learners received feedback on the ideal construction of a map as well as the content they displayed. The feedback also included an initial rubric with the following criteria, namely accuracy, utility, clarity, integration, organisation and creativity. The learners were, however, assured that their performance on the mapping task did not form part of their assessment. The learners were also expected to memorise the content and to prepare for a formative assessment.

These initial maps were used to investigate some of the scoring schemes described in the literature, and to develop a scheme which was suitable for this subject. Analysis of this first cycle of the action research project was necessary to develop the later stages in which the scoring scheme was devised and refined. The scores on the concept maps were not included as part of the formal assessment for this unit.

Concept-mapping as assessment tool

Two weeks later, there was an appropriate point in the learning unit sequence for a second concept map to be set. There had been time for reflection on the part of both the facilitator/researcher and the learners on the efficacy of concept maps. Both the list of terms and the lesson structure for the second map were developed, using experience gained from the first map. In the third learning unit under trial, "Understanding Motivation", the learners were again asked to draw a concept map using information from the source mentioned. These concept maps were intended to display the links between fundamental aspects of "Motivation", and hence represented a deeper level of understanding. The scoring system could be explained before the maps were set; a rubric including the assessment criteria and standards was provided; and the scores obtained could then become part of a formal assessment. The use of action research allowed the researcher to adjust and refine the project as it progressed in response to reflections on earlier stages. The rubric to score the maps was one aspect of the study which resulted in particular development as the project progressed. Different scoring systems used in the literature were explored because there was no specific format for scoring maps in management. The criteria set out in these systems were modified and included in a rubric that was suitable for the specific module that was investigated as adapted from Kinchin, Hay and Adams. (2000,57) (see Table 1).

Table 1: Scoring rubric

Criteria	Standards
Accuracy	• Content is factually correct
Utility	• Links are correct, complete or useful
Clarity	• The structure and the content knowledge are clear
Integration and complexity	• The quality of the map reflects the complexity of relationships
Organisation	• The map reflects the logic flow and relationship of concepts or ideas graphically and visually
Creativity and stability	• The extent to which creative ideas and creative structures to represent content are used
Hierarchy	• One level only • Several justifiable levels
Processes	• Simple association no interactions • Complex interactions at different conceptual levels
Conceptual development	• A narrow holistic view • A holistic view
Represents	• Lesson sequence • Meaningful learning
Assessment criteria	3=Achieved, 2=Correct but limited, 1=Needs revision, 0=Not included

The second maps displayed a good outline of the basic concepts. The maps also portrayed creativity and the content was factually correct. The links, organisation and structure of the map in general were also clear.

Pre-structured concept map

Finally, in the last learning area under trial "Introduction to Stress" a pre-structured concept map created by the facilitator/researcher, as part of the instruction process, was provided to the learners. Information was again obtained from the prescribed source and created by means of the computer-based concept map tool MindManager X5. The map was intended to emphasise the conceptual links that the learners needed to build an integrated knowledge structure. It was once again expected from the learners to memorise the content and to prepare for a formative assessment.

Achievement measurements

Formative assessment

At the end of each learning unit the learners wrote a formative assessment test to evaluate their knowledge on Performance Appraisal, Decisions, Motivation and Stress. The tests

consisted of a collection of questions that asked learners to outline, list, define and specify the information from the mentioned units.

Formal summative assessment

At the end of the semester the learners wrote a paper on all the learning units. The question on Performance Appraisal asked the learners to outline certain advantages; the question on Decisions involved the drawing of a concept map; while in the Motivation learning area it was expected from the learners to reflect on and apply the motivational theories to their own experiential learning environments. In the last area, Stress, the question expected the learners to differentiate between two aspects.

Questionnaire survey

The questionnaire was designed to evaluate the learners' perception of the effectiveness of concept-mapping. A set of questions and measures of individual preferences were included in the questionnaire. The learners were asked to indicate their perceptions regarding how successful or effective the concept-mapping was upon their own learning. The questions, to which the answers consisted of a "Yes" or a "No" answer only, provided information about learners' perceptions, reactions, attitudes, feelings, and experiences. The use of a "yes/no" answer was decided upon in order to encourage a more objective approach to assessing the effectiveness of the intervention.

Assessment results

The average formal lecture test scores (77%) were significantly higher than the average pre-structured map scores (61%) during the formative assessment events (see Figure 4.4). This could be an indication of a better short-term retention of the formal lecture. However, no significant differences were found in the exam scores of the two interventions (58% in opposition to 68%) during the formal summative assessment. It appears that these two teacher-centred approaches were equally ineffective when compared with the learner-centred and self-directed concept map interventions.

Both the average formative and summative scores of the self-directed concept map intervention, 83% and 79% respectively, were higher than the scores obtained during the formal lecture and the pre-structured maps. These results support the notion that when learners are active in the learning process academic performance increases. Also a noteworthy finding is the increase in long-term retention among the learners when they designed and constructed their own maps compared to when they were passive in the learning process. This finding is supported by Novak and Cañas (2006,7).

On the other hand, during the intervention where it was expected from the learners to reflect on and apply the map content, learners experienced difficulty in extracting relevant information from their maps and integrating concepts to form a logical solution to the proposed problem. The average score obtained was 56%. These findings suggested that individual concept map tasks can improve academic performance but it does not guarantee that conceptual change will take place.

Questionnaire results

The usefulness of concept-mapping was positively acknowledged by most of the learners and the following is a summary of the learners' remarks. Students were asked to respond to the following question: Can a concept map increase your marks? The majority of the learners (97% in cycle one and 84% in cycle two) reported that concept-mapping would improve their marks. The reasons for improved marks that were put forward were that concept maps displayed important information in a concise manner and that information became easier to remember. The following remarks were made:

"When I am writing a test I can imagine the mind map in front of me …"

"It is easy to study and hard to forget"
"Study becomes less but remember more"
"It is short and descriptive"
"It gives you a mental picture of the work"
"It is a fresh approach to learning"
"It represents knowledge in a logical way" (Afrikaans).

In reply to the question: Do you find it difficult to construct a concept map? Almost one third (34%) in the first cycle and a half (52%) in the second cycle mentioned that they found it difficult to determine the key concepts and they were also afraid that they would miss important information. The rest of the students indicated that they did not find the task difficult. They reported that they took the headings and subheadings of the content to be learned and then filled in the rest.

When asked if a concept map could improve memory, a total of 91% of the students in the first cycle and the whole group in the second cycle answered positively. Most of the students found the use of colour and pictures the most valuable. Some of the comments are listed below:

"It gives the whole lesson in a picture"
"Remember longer and it is easier to recall"
"Makes a big job small and my brain can grab the whole information"
"A picture is worth a thousand words".

These comments mirror those of Wandersee in Kinchin *et al.* (2000,44) who claims that "to map is to know". When asked if they preferred to draw their own maps, almost half of the students in both cycles preferred to construct their own maps, because they learned while creating their maps. The other half found it a time-consuming task and expressed uncertainty that they would not be able to include all the information.

Influential findings from cycle one

The first cycle in this action research inquiry fit the description of Biggs's explanation of the learning process seen from a constructivist point of view. According to Biggs (1999,12), learning is enforced by active engagement in learning tasks and not through direct teaching This active selecting and construction of knowledge (the individual process of creating concept maps) thus explain the differences in test scores and concept map quality which draw attention to the relationship between effort (map quality) and achievement (assessment scores).

This generative learning strategy could increase test and exam performances. However, the fact that conceptual change did not occur can be linked to the lack of social interaction between and collaboration with co-learners and researcher. According to Gravett (2005,21), this social constructivism leads to "shared meaning or the co-construction of knowledge". Biggs (1999,13) emphasises that learning takes place through the construction of knowledge and eventually meaning by both peer and educator social actions. This statement adds to the view of Gravett (2005,21) that, in order to make meaning of knowledge, learning should be an interactive process - thus part of collaborative teaching-learning situations. Van Huizen, Van Oers and Wubbels (2005,271-272) support this notion based on their perspectives on the Vygotskian theory which implies that both the course of action and the person taking part are crucial in any developmental process. Kinchin and Hay (2005,186) view social dialogue as a crucial part of knowledge formation and suggest that it upholds a "sociocultural" view of learning. The potential of collaborative learning to encourage conceptual development as a result of the shared perspectives during social interactions recognised by Quinn Mintzes and Laws (2004,15) and Kinchin *et al.* (2000,54) thus determined the actions in the second cycle.

An outline of the second cycle

The role of social action and interaction in developing conceptual change was recognised in the concept map tasks of the following year (2006). It is within this framework that the second cycle of the action research inquiry was planned. Thus, to facilitate the process of conceptualisation, collaborative group work was included during the construction of maps.

In the learning unit "Understanding Motivation" with a new group of learners in 2006, the learners were again prepared for concept-mapping tasks by means of an information lecture. The learners were asked to draw a concept map of the various motivational theories while interacting with co-learners in a small group. In addition, they had to use their maps as a basis for a group discussion on the application of the different motivational theories in their own experiential work environment. The small group interaction was followed up by asking learners to share the results of the interaction with a larger group. Inputs and feedback from the groups then led to a class discussion, after which each learner added further perspectives to their own maps gained through the interaction with the group members and input from the researcher. This approach served as a vehicle for reasoning and a starting point for conceptual development, since the learners in the group brought different perspectives to the shared construction of a map. Kinchin (1998) describes this progression towards conceptual change as a process of building collective meaning, while Gravett and Swart (1997,123) maintain that, if this process adds up to "true learning", conceptual change will take place.

During the formative assessment on the motivation learning unit it was once again expected from the learners to apply the motivational theories to their own experiential learning environments. The test scores showed a remarkable increase from the previous scores obtained in cycle one when no interaction took place. The average assessment score for cycle one was 56%, while the score in cycle two increased to 74%. The response to the question also varied considerably from the attempts in the first cycle. The learners extracted relevant information from their group concept maps and integrated the concepts into solving the proposed problem. The learners previously only referred to the different motivational theories without linking related concepts. During this second cycle they brought their own experiences gained through the social interaction construction of maps into answering the question. Theories were also transformed to fit the experiential environment as well as their individual perspectives.

These findings indicated that the learners had acquired the ability to construct and transform knowledge through this dialogical task. This collaborative approach to concept-mapping thus led to conceptual change. When introducing concept-mapping as an instructional or learning scaffold with the aim of ultimately developing it into a generative learning strategy, the implementation thereof should therefore take place in a collaborative learning environment. This social interaction supports learners within a group to capture their developing ideas, transforming them, and making new associations (Marchinko 2004,1) in order to develop conceptual change.

RATIONALE IN TERMS OF EDUCATIONAL IDEAS

Considerable changes in higher education (HE) have emerged over the last decade. The sudden increase in contemporary forms of learning facilitation and assessment approaches has resulted in efforts to delineate facilitation and assessment competencies within the changed nature of educational approaches. Concept-mapping shaped around the learning situation, as an adaptable scaffold, has the potential to initiate and maintain this progression towards self-direction and self-regulation (De Simone, Schmid & McEwen 2001,279). Concept-mapping as a generative learning strategy can thus set in motion this proposed shift from teacher dependency to learner independency and, as a result, holds the potential to improve academic proficiency (Peterson & Snyder 1998,27). In view of the fact that the focus of learning shifts from teacher to learner during concept-mapping (Laight 2004,232), the intent of learner-centred learning can be reached. In support of these claims Chastonay, Papart, Laporte, Praplan, Brenner, Walker, Rougemont, Guilbert and Lagoutte (1999,21) state that concept-mapping not only enhances learner responsibility and autonomy, but also leads to increased motivation, retention and integration of

knowledge, as well as deeper levels of learning which in due course result in more meaningful learning.

To reach effective learning Biggs (1999,11) proposes that an arrangement of constructive alignment should be pursued. According to the author this alignment includes a link between constructivism in learning through appropriate learning activities (Biggs 2003,1) and alignment in teaching as well as assessment, where teaching is basically a vehicle for learning. It is thus important that facilitators create events or activities in which learners can construct their own knowledge.

Over and above the possible role that concept-mapping can play in learner-centred learning and assessment it is also related to a constructivist approach to learning and it provides a foundation for constructivist teaching (Kinchin 1998; Kinchin *et al*. 2000,45; Kinchin 2006,79). This notion supports Biggs's constructivist-driven teaching (1999,10) mentioned previously. The researcher thus regarded *concept-mapping* as a good foundation to impose constructivism in teaching and a foreseen outcome, as well as constructivism in learning. Concept-mapping as a constructive or generative learning and assessment strategy was therefore seen as having the potential to not only assist the shift from teacher to learner, but also facilitate more effective learning.

Concept mapping as an assessment tool

Concept maps are seen by Quinn *et al*. (2004,12) as both easy to use and an alternative for traditional methods of assessment. It reveals not only what learners understand, but also the gaps in their knowledge (Ebener, Khan, Shademani, Compernolle, Beltran, Lansang, & Lippmana 2006,640) or their misunderstandings (Novak & Cañas 2006,5; Lim, Cheng, Lam, & Ngan 2003,70). West, Park and Sandoval (2002,820), Rebich and Gautier (2005,364), Quinn *et al*. (2004,12) and Williams (2004,33) see concept-mapping as a powerful assessment device that explores and portrays the structural complexity and validity of knowledge. The researcher could therefore use concept-mapping as an assessment tool (Peterson & Snyder 1998,15) or as a vehicle to record conceptual change (Kinchin, De Leij & Hay 2005,12; Gravett & Swart 1997,124) which is indicative of meaningful learning and thus is a great design for assessment.

EVALUATION

This investigation into concept-mapping as a generative learning strategy included both the researcher/teacher and the learners in a process to improve learning, an approach aimed at changing teaching from teacher-centred practices to "learning-centred dialogic teaching" (Gravett 2005,41). This process can be described as transformational learning, which is the development from existing beliefs towards more justifiable beliefs through a process in which alternatives are considered (Gravett 2004,260). The researcher places this investigation within this perspective and sees the "existing beliefs" as teacher- and learner-centred learning, while the "justifiable beliefs" are seen as learning-centredness and concept-mapping in tandem with collaboration as the "alternative" to be considered.

The benefits of concept-mapping were realised through both quantitative and qualitative observation techniques. These quantitative and descriptive data presented indicate that concept-mapping contributed not only to achieving efficacy, but also to conceptual development. The researcher sees these positive outcomes as effects of both the active generation of knowledge through the act of mapping and the social interaction during the collaborative concept map task in cycle two. The majority of the learners in both cycle one and two positively acknowledged the use of concept-mapping and they saw it as an adjunct to their learning. The findings of this investigation confirm works by others that indicate that the use of concept-mapping as a teaching/learning tool can lead to achievement gain, meaningful learning and ultimately conceptual change (Clayton 2006,202; Hauser Nückles & Renkl 2006,248; Chularut & DeBacker 2004,259; Chastonay *et al*. 1999,25; Quinn *et al*. 2004,15). Furthermore, since empirical research points towards the fact that during the process of learning concept-mapping also encourages self-regulation and self-efficacy

(Chularut & DeBacker 2004,260), a deep approach to learning (Laight 2006,66) and motivation (Laight 2004,229) is, among other factors, associated with academic achievement. Academic success can therefore be placed within reach of higher education learners by nurturing these factors through concept-mapping. Moreover, this increase in self-regulation, self-efficacy, a deep learning orientation, and motivation emphasises the value of this investigation.

A major advantage of concept maps is that they are a visual way of communication (Freeman & Jessup 2004,159). If used correctly mind mapping encourages high-level (Pardue, Tagliareni, Valiga, Davison-Price & Orehowsky 2005,56) and critical thinking which facilitates problem-solving (Russel 2004,1; Farrand, Hussain, & Hennessy 2002,427; Peterson & Snyder 1998,27). In addition, learners and facilitators appear to be satisfied with the usefulness, ease of use and effectiveness of concept-mapping as a learning strategy (Freeman & Jessup 2004,166). Many additional advantages exist for both facilitator and learner.

Advantages for higher education facilitators

Inducing learners to reveal their understanding of complex conceptual learning areas is a real challenge for facilitators. Concept maps can assist in this process because the learners can visually express their view of complex knowledge areas. Concept-mapping can also serve as an instructional tool for facilitators (Peterson & Snyder 1998,27; Lim *et al*. 2003,56). Pre-constructed concept maps presented as a teaching/learning activity are valuable as a strategy to facilitate learning (Alpert & Grueneberg 2001,36). In addition, concept-mapping results in "teaching to all types" (Laight 2004,229), since it accommodates a variety of preferred learning styles (Peterson & Snyder 1998,7) often neglected by traditional instruction (Laight 2004,232).

Concept maps further allow facilitators to deal with subject matters in greater depth since a map provides "…a framework that can be viewed, elaborated on, adapted and developed over a period of time" (Fisher in Lim *et al*. 2003,56). Mapping also stimulates the sharing of ideas. It is a visual means to build concepts from data (individually and collectively), which makes it a useful educational strategy to facilitate group work activities (Chularut & DeBacker 2004,248). Over and above the fact that concept maps are helpful instructional and learning devices (Gravett & Swart 1997,125) they can also provide a means to assess both the process and product of knowledge production (Gravett & Swart 1997,124). This process (learning activities) and product (learning outcomes) represent two of the levels in Biggs's 3P model (Biggs 1999,18-19) of teaching and learning. And since concept-mapping encourages learners to reflect on the key elements of their prior knowledge or experience and to display and communicate to others their knowledge of a learning area or domain (Alpert & Grueneberg 2001,36), the presage level of the 3P model is also contained in the concept-mapping process which has the ability to link previous and new knowledge (Novak & Cañas 2006,2; Williams 2004,35).

Advantages for higher education learners

Concept-mapping can be used to help learners learn how to learn (Novak 2004,23; Quinn *et al*. 2004,15; Gravett & Swart 1997,124; Peterson & Snyder 1998,11; Fraser 1996,1), since it condenses and simplifies advanced study material. For example, the use of ineffective learning strategies during problem-based learning (PBL) can obstruct learners' ability to define and solve problems in a purposeful way (De Simone *et al*. 2001,264). Concept maps have the ability to reveal a complex structure of ideas or multiple links among concepts (Lim *et al*. 2003,57). Concept-mapping therefore structures the learning process more effectively (Laight 2004,232) with the result that higher-quality learning takes place. Concept-mapping as an instrument to demonstrate knowledge stimulates learners to explore their conception of key ideas and mapping assists them in making significant patterns of their knowledge (Lim *et al*. 2003,55). In addition, it promotes creative thinking (Novak & Cañas 2006,2) by helping learners to generate ideas; to see logical association; and to view issues from a holistic perspective (Quinn *et al*. 2004,15; Peterson & Snyder 1998,12).

General disadvantages

Several authors reported on the advantages and positive rewards of concept-mapping experienced by learners (Li-Lung 2004,9; Xiaoxue 2004,371; Chularut & DeBacker 2004,248; Quinn *et al*. 2004,12; Novak 2004,39; Riley 2004,244; Freeman & Jessup 2004,166). However, like all learning strategies, concept-mapping is not a cure-all; it might not suit all learners or all learning situations. Learners in higher education are sometimes fixed on traditional learning strategies and may resist new teaching/learning activities and they could also lack the ability to construct their own maps (Quinn *et al*. 2004,15). Although easy to use, learners should be guided and instructed in the process of using concept-mapping as a study strategy (De Simone *et al*. 2001,282; Farrand *et al*. 2002,430). Furthermore, all types of concept-mapping strategies are not equally effective for different educational outcomes (Xiaoxue 2004,371; Lee 2004,112). The possibility that not all learners will gain the same benefit by using concept-mapping should thus be considered when implementing concept-mapping as a generative learning or assessment strategy.

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