A QUALITATIVE ENQUIRY INTO LEARNER EXPERIENCE OF UTILISING CONCEPT MAPS AS A LEARNING METHOD IN PHYSICAL SCIENCE

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ABSTRACT

The aim of this study was to describe the experience of learners who utilise concept maps as a learning method in Physical Science. The reasoning strategy employed was induction so that theory could be generated regarding the subjective experience of concept maps by learners. Qualitative methodology was accordingly employed as the research approach, utilising a focus group interview and spontaneous sketch questions as the data collection instruments. Analysis of the phenomenological data shows that learners have a rich complexity of experience surrounding the use of concept maps as a learning method. The category most evident, which forms the essence of learner experience in this study, is that concept maps promote learning.

OPSOMMING

Die doel met die studie was om die ervaring van leerders, wat begripskaarte as leermetode in Natuur- en Skeikunde gebruik, te beskryf. Induksie is as denkstrategie toegepas ten einde teorie betreffende leerders se subjektiewe ervaring van begripskaarte te genereer. Dienooreenkomstig is kwalitatiewe metodologie as navorsingsbenadering gevolg, deur van 'n fokusgroeponderhoud en naïewe sketsvrae as datainsamelingsinstrumente gebruik te gemaak het. Die analise van die fenomenologiese data dui daarop dat die ervaring van leerders betreffende die gebruik van begripskaarte as leermetode ryk en kompleks is. Die mees opvallende kategorie, en wat in hierdie studie die kern van die leerders se ervaring vorm, is dat begripskaarte leer bevorder.

BACKGROUND AND ORIENTATION TO THE STUDY

Education in a democratic South Africa implies that all South African learners should have access to effective education so that inequities may be eliminated and the ability and skill of each learner optimally improved (De Wet, 1995:1).

There has been widespread criticism of the existing Physical Science syllabus in South Africa. Critics have labeled it as "outmoded, academic, content-driven and decontextualised in that there is little attempt to relate the syllabus to the everyday life experience of the learner" (CEPD, 1995:3).

Apart from low numbers of pupils in this learning area, especially in the senior secondary phase, from a perusal of the literature, Mehl (1992:1) is of the opinion that rote recall and memorisation is a common practice in South African schools. Existing South African Science syllabi are heavily dominated by examinations which stress rote learning, factual recall and application of standard algorithms, rather than encourage problem-solving, creativity and conceptual thinking (NEPI, 1992:3). This results in learning being approached superficially. It leads to poor retention of knowledge in the long term, poor knowledge reproduction in tests and examinations and an ineffectual basis for further learning.

In the past ten years, an appreciable amount of research has been conducted on misconceptions, alternative concepts, learning and techniques of learning in the instruction and learning of Physical Science concepts (Basson & Schoeman, 1993:2). Recent research in the area of instruction and learning emphasises goal-directed and constructive action on the part of the learner for the content that must be learnt. In order to learn constructively, the learner must give meaning to the specific learning experiences (Basson, 1993:50; Biehler & Snowman, 1993:430-440; Grant, Johnson & Sanders, 1990:3; Rutherford & Ahlgren, 1990:188-193).

Researchers have found that learners who utilise constructivist learning methods in the natural sciences understand the content better, discuss and solve problems in the subject better and also enjoy practical laboratory work more (Pintrich, Ransom, Kozma & McKeachie, 1987:673; Roth, 1994:200, 215-219). One such constructivist learning method is that of the concept map (Jegede, Alaiyemola & Okebukola, 1990:952).

A concept map is a schematic design for the representation of a set of concepts in which the understanding of the concept is inherent to the framework of the concepts (Wandersee, 1990:923). It further serves as a metacognitive strategy in that the learner thereby regulates his/her learning process. The learner is assisted to view the concepts and relationship between concepts in a holistic fashion, and thus meaningful learning is facilitated (Jegede **et al.** 1990:952; Novak, 1990a:29; Okebukola, 1992a:166).

PROBLEM STATEMENT

As most teachers accept that concept maps are an effective learning method in any subject, some teachers in South Africa integrate them as part of Science teaching in order to address the problem of rote learning in this area. In this way, learners may give meaning to their specific learning experiences so that meaningful learning is facilitated. Although learners use concept maps no information exists on their experiences or their views about them. The question, which arises, is: How do learners experience concept maps as a learning method in Physical Science?

RESEARCH OBJECTIVES

The aim of the study is to explore and describe the experience of learners with concept maps as a learning method in Physical Science.

RESEARCH DESIGN AND PROCEDURES

The design is explorative, descriptive and contextual in nature. The learners' experience of concept maps in the process of learning Physical Science in a specific school is explored by means of qualitative research methodology. The findings are utilised to describe the learners' experiences.

DATA COLLECTION METHODS

The data collection methods are focus group interviewing and spontaneous (naïve) sketches.

Focus group interviews

Focus group interviews involve a homogeneous group of people in a social interaction. The aim of a focus group interview is to gather qualitative data by means of a goal-directed discussion (Krueger, 1994:37). It is a person-oriented, adaptable research method suitable to be used with any type of participant. It is also uniquely suited to an in-depth study. The person is a social being who is in constant interaction with others. In such a focus group interview the members influence one another by means of their responses, members make decisions and air their experience and views as they are formed. A focus group interview places its members in an experiential situation. Inhibitions are more easily discarded in a group as opposed to an individual interview (Ferreira & Puth, 1988:166; Krueger, 1994:34).

Spontaneous (naïve) sketch questions

The spontaneous (naïve) sketch question is a descriptive method in which the respondent is asked for a personal description of the phenomenon in which the researcher is interested (Creswell, 1994:159; Giorgi, 1985:8-14).

Spontaneous (naïve) sketch questions provide a frame of reference for the respondents' answers and place minimal restriction on the answers and the meaning of the answers (Kerlinger, 1986:442).

CONTEXT

The context of the study is a high socio-economic, Afrikaans secondary school in the Vereeniging area. The grade 10 Physical Science (Higher Grade) learners were introduced to the subject matter by means of traditional teaching. Thereafter they were exposed to the concept mapping technique as described by Ault (1985:41), Basson and Schoeman (1993:3-5), and Novak and Gowin (1984:25-34) for seven school days. The group was exposed to concepts, related concepts and the relationships between concepts. The learners were taught to compile their own concept maps on different concepts in electric current and requested to provide a copy for the teacher. The learners retained the original maps for learning purposes. An example was shown and demonstrated before learners designed their own maps. The learners were taught to design their own maps according to the method of Novak and Gowin (1984:25-34) and according to the orientation in the workbook by Basson (1993:3-5). A separate concept map was designed for each of the following main concepts:

- Strength of electrical current
- Cells
- Resistance
- Measuring instruments
- Differences of potential

POPULATION AND SAMPLING

The population consisted of 27 grade 10 learners of Physical Science (Higher Grade).

Sampling

Participants in a focus group usually consist of respondents who are familiar with the topic. The focus group requires homogeneity as its characteristic, along with sufficient variation in the group in terms of differing opinions. Traditionally the group consists of four to twelve members (Axelrod, 1975:5). A sample of six grade 10 learners was randomly selected from the population by means of a random table from an alphanumerical list. The total population was selected for spontaneous sketches.

DATA COLLECTION

Focus group interview

A focus group interview was conducted with six learners by an independent interviewer. The interview was conducted after school hours in a neutral venue. In this study the media centre at the school was chosen because it is familiar to the respondents. The Physical Science laboratory could have evoked anxieties or prejudice. Participants were encouraged to wear casual civilian clothing to create a relaxed atmosphere and avoid the perception of a classroom and school situation.

In order not to be leading, and not to create blockages in communication, but rather to encourage people to provide information, an open-ended question was designed. It involves the type of question to which a "yes" or "no" response cannot be given (Müller, 1993:31). The interview was both audio- and video-taped. A verbatim transcription of the discussion was made in the interests of validity and reliability, in that reliance on the memory of the interviewer or researcher would constitute a threat to validity. In this interview the question was: "How did you experience concept maps?"

Spontaneous (naïve) sketch questions

The spontaneous sketch questions, which were posed, were:
What is your understanding of a concept map?" and
What is your experience of learning in Physical Science with the aid of concept maps?"

These questions were posed at the end of a test on electrical current, for which the learners had utilised concept maps to learn, without the learners having prior knowledge that the questions would be posed at this time. The reason for this was to elicit their spontaneous experience of concept maps. A test situation was utilised so that they could not enter into discussion with one another. The question was answered in written format on the test answer sheets.

DATA ANALYSIS

The transcribed focus group interview and spontaneous sketches were initially analysed separately by the researcher and independent coder, who then met to discuss the generated categories. This prevents the researcher from eliciting responses that reflect her own expectations (Creswell, 1994:155; Krueger, 1994:129; Poggenpoel, 1993; Strauss & Corbin, 1990:61-74, 96-115).

Considerations of trustworthiness in this study

Trustworthiness was ensured in several ways in this study. The methods of sampling, data collection and data analysis were executed along acknowledged lines. While the researcher is familiar to the respondents and instructed them in the use of concept maps, an independent person conducted the interview. Through the application of two data collection methods (focus group interview and spontaneous sketch questions), triangulation was possible. The use of an independent coder contributed to the level of trustworthiness. The literature control provided for further verification of findings.

Ethical considerations

Prior consent was obtained from parents and the school principal, as the respondents are adolescents. The group members had voluntary choice of participation. Participants were assured that all the data would be anonymous.

RESULTS AND DISCUSSION

Table 1 provides a combined schematic representation of the four main categories and subcategories of learner experience which were generated from the coding of the focus group interview and spontaneous sketches.

A literature control was done after the identification of the main- and subcategories to verify findings. The literature control and findings were discussed according to the categories in table 1.

Advantages of concept maps

Concept maps promote learning in Physical Science

One learner testified that, *"...when you've drawn up the concept map, the work looks so much less and when you look at it, it looks so much less than it really is, then it makes it nicer for me to learn..."*. This indicates that condensed facts provide a logical exposition of the content and thus make learning more pleasant. The learning process utilising concept maps also gives the learners a sense of satisfaction as they feel that they have achieved something. When a learning method provides satisfaction because it makes learning easier, it stimulates and motivates the learner to use the learning method. *"...certain concepts sort of follow on one another, so as you learn the one concept you learn what follows on it; the next one puts it together and so you learn easier..."*

Novak and Gowin (1984:7) as well as Novak, Gowin and Johansen (1983:625) advocate Ausubel's theory where learners use concepts as a basis to construct meaning. Meaningful learning occurs when new information is related to and integrated with existing knowledge (Edmonson & Novak, 1993:548; Fisher, 1990:1009; Novak, 1990b:941-943; Roth & Roychoudhury, 1993a:503, 525). Concept maps relate to meta-cognition as they assist learners to organise their cognitive frameworks (Jegede **et al.** 1990:952, 956/7; Novak, 1990a:32; Starr & Krajcik, 1990:988/9, 997; Wallace & Mintzes, 1990:1034). As learners develop and acquire experience, they become more aware of meta-cognitive knowledge, as well as of the relationship, which exists between meta-cognition and successful learning (Royer **et al.** 1993:226; Towbridge & Wandersee, 1994:460). According to Okebukola (1992a:154) concept maps guide the learner from learning by recall and memorisation to active meta cognition. Concept maps can play a significant role in facilitating meaningful learning in that new information is brought into relation with existing and relevant concepts in the learner's cognitive structure (Cullen, 1990:1067; Lloyd, 1990:1020; Moreira, 1979:283; Okebukola, 1992b:218, 221; Wandersee, 1990:930; Willerman & MacHarg, 1991:705). Another advantage is that concept maps have an affective component in that they reduce tension and enable positive sentiments towards learning (Novak, 1990b:942, 944).

Table 1

MAIN AND SUBCATEGORIES IDENTIFIED BY THIS STUDY

1) Advantages of concept maps
• Concept maps promote learning in Physical Science
• Thinking is promoted by the designing of concept maps
• Concept maps promote understanding of subject content
• Concept maps promote the recall of knowledge
• Concept maps are appropriately utilised
• Repetition / reconstruction of concept maps is unnecessary
• Sufficient prior knowledge of the subject is required for the design of a concept map
• Concept maps are comprehensive of the information for which they are designed
2) Characteristics of concept maps
• Concept maps contain links between the different related concepts
• Concepts in a concept map flow in progression from one concept to another
• Concept maps require prior exploration of the content to be included
• Concept maps contain only core concepts
• Concept maps organise the learning content
• Concept maps are a logical, simplified exposition of the content of Physical Science
• Concept maps promote learning
3) Uniqueness of concept maps
• Concept maps are unique to the learner who designed them
• Concept maps are pliable in that they may take on any form
4) Limitations of concept maps
• Concept maps are not suitable for lengthy explanations
• Concept maps impede learning
• Concept maps are time-consuming and require repetition and revision
• Concept maps contain equal risks of failure as other learning methods
The future use of concept maps is uncertain for some learners

Thinking is promoted by the designing of concept maps

The learners experienced that the process of learning with the aid of concept maps goes hand-in-hand with thinking in that the learner places his/her "thoughts" on paper *"... concept maps are like thinking on paper...",* and *"...it's what you think, but just written down on paper...".* The process of designing concept maps teaches learners to think, *"...it teaches you to think...".* Roth (1990:33) says learners think more intensively about the subject whilst drawing concept maps. Concept maps give rise to meaningful learning in that the learner becomes aware of the cognitive learning process (Roth & Roychoudhury, 1993a:504). Concept map exercises require that learners reflect more deeply and divergently (Ault, 1985:38, 43; Fisher, 1990:1009; Starr & Krajcik, 1990:989, 997; Towbridge & Wandersee, 1994:472).

Concept maps promote understanding of subject content

When the learner uses concept maps in learning it leads to better understanding of the subject content of Physical Science. When the learner understands the content with the aid of concept maps, he/she knows the content *"...so that when you've drawn your concept map, you won't be caught not knowing answers, because if you understand it , you know it...(subject content)" ; "...it helps you to understand better this way..."* The use of concept maps assists in understanding foreign or difficult abstract concepts and they also help learners to better understand concepts and the relation between concepts (Fisher, 1990:1002; Roth, 1994:213; Roth & Roychoudhury, 1993a:503; Jegede **et al.** 1990:95/6; Okebukola, 1992b:218; Starr & Krajcik, 1990:999; Lehman, Carter & Kahle, 1985:665; Shymansky **et al.** 1993:752).

Concept maps promote the recall of knowledge

Respondents commented as follows: *"...what you actually do, you look at the word, and then you get a whole story in your head, because it's what it revolves around, and then the whole thing is so much easier...".* This confirms that concept maps help form a holistic image of a concept and its relationships, and this "picture" is easily remembered because the learner obtains true insight and understands the content. By visualising knowledge, it is better recalled according to Halpern (1992:5) and Novak **et al.** (1983:635, 637). Willerman and MacHarg (1991:709-710) state that the retention of learners who utilise concept maps is better than that of those who do not use concept maps.

Concept maps are appropriately utilised

It appears from the study that concept maps are more suitable for certain sections of Physical Science content, and these are more "easily" placed in a concept map than other sections *"...because I think a concept map can work very well, or it can't work at all. Because in some places it works very well for you, it's going to save you time and you'll immediately know the work. There are places where it works easily and some where it doesn't, in other words where you have to make lots of maps for one chapter and then I don't think it's so effective. Then it will work with some things, but not others...".* In the literature, this view is supported by Moreira (1985:16) who says concept maps provide for a wide variety of subjects and age groups. Concept maps may be applied in any learning content, and in learning content of varying degrees of difficulty (Edmondson 1995:778) . For some learners concept maps were an effective learning method, but for some they were not *"...just about nobody has the same way of learning. That's why concept maps will work for certain people ... we tried it and we saw that sometimes it can and sometimes it can't for some people...".* When examples of concept maps are provided for learners, their own concept maps are more complete, accurate and provide more information, according to Willerman and MacHarg (1991:706). McDonald and Czerniak (1994:9) believe that concept maps lead to the establishment of relationships between different scientific fields in that concepts are effectively placed in the learners' cognitive structure (Ault, 1985:42). A self-constructed concept map provides a version of the learner's conceptualisation of the subject (Okebukola, 1992a:154). Wandersee (1990:924) says the quality and quantity of a concept map depend on the information that the learner has selected from the learning contents.

Repetition or reconstruction of concept maps is unnecessary

For some learners it was necessary to design a concept map for a section of content in Physical Science only once to "know" their work well. The first and original concept map on a section of content was sufficient for these learners to accept it with confidence as an accurate reflection of the content in question.

When revision for a test or examination occurs, this original concept map is again utilised. *"...why would I want to design another map, I understand the one I drew up very well...". "...if I draw up a concept map well when I read the work the first time, then I keep it, I'm not going to redo it time and again...". "...that's why I rather make one good map and then I'll use it to learn all the time over and over, (in test and exam situations) because I understand it well..." .* The true educational value of concept maps lies in the fact that the learner spends a certain amount of time on the learning content and summaries immediately after the lesson, rather than a few days before the examination (Towbridge & Wandersee, 1994:471).

Sufficient prior knowledge of the subject is required for the design of a concept map

The more comprehensive and complete the prior knowledge of the learner, the easier the design of the concept map *"...it's really about how well you know your work, if you first know it well then you can easily draw a short concept map...".* Concept maps should preferably be drawn once the learner is both familiar with and understands the subject so that concepts and their relationships may be meaningfully integrated (Grant **et al.** 1990:2; Moreira, 1979:285; Novak & Gowin, 1984:22/3).

Concept maps are comprehensive of the information for which they are designed

For a concept map to be effective it must contain all the relevant information to ensure that the learner has captured the totality of the relevant content *"...you see that for things to fit together well you must include these things so that it's completely captured. Everything that must be there must be in one concept map, not in two that do the same thing..."* Novak and Gowin (1984:15) and Wandersee (1990:930) conclude that concept maps provide a holistic image of what learners know.

Characteristics of concept maps

Concept maps contain links between the different related concepts

Concept maps clearly display the links between related Physical Science concepts which enabled the learner to immediately see these relationships *"...there's a sort of linking of what fits with what, how it's formed, what happens as result of what..."* and *"...you begin with a big concept and then all sorts of other ones follow in it, and that links the whole thing together...".* The hierarchical integration and linking of concepts give rise to meaningful learning (Ault, 1985:38/9; Novak & Gowin, 1984:15, 28, 78; Moreira, 1979:283).

Concepts in a concept map flow in progression from one concept to another

Progressive/sequential concepts are linked with one another in a concept map, as are the cross-connections between concepts. All the concepts thus required within a specific topic are incorporated in one concept map to form a whole *"...when you learn the one concept then you learn what follows on it, the next one, and that makes the work come together and you learn easily..."* and *"... everything is one after the other and not in different places in the chapter, so you know exactly what all goes under each concept...".* The correct linkage between concepts is more important than their correct hierarchical positioning (Roth & Roychoudhury, 1993a:509, 522; Starr & Krajcik, 1990:988).

Concept maps require prior exploration of the content to be included

The learner cannot design a concept map before he/she has gathered all the necessary information to be contained in it. If the learner has not gathered this information, this could in all likelihood lead to the design of two separate concept maps about precisely the same topic. To eliminate this duplication, the learner must first explore the content and ensure that all the relevant information is available (Edmondson, 1995:779; Roth & Roychoudhury, 1993a:525; Wandersee, 1990:924). *"... you first read through the chapter and then you look ... you must have an overview of the work before you can design the map..." "... you have to first understand before you draw the map, if you don't understand you're probably going to make a mistake..."*

Concept maps contain only core concepts

Concept maps contain only the core Physical Science concepts and the relationships between the concepts. In this way learning and the recall of the content is facilitated. For the learner to identify the core concepts, he/she has to understand the concept and its relationships. When the learner understands a concept and its relationships, he/she does not need to return to the textbook to revise the content *"...if it's a good concept map you don't have to go back to the book. You must know that when you've gone through that map and you know it well, then you will do well, as well as you would have done using the book. So you don't go back to the book when you've learned the map, it will be a waste of time. It must be so that when you've learned the map you'll know everything..."* In addition to concept maps containing only core concepts, learning is more meaningful when the interdependent core concepts appear in a hierarchical network with relationships indicated (Ault, 1985:39, 40; Wandersee, 1990:924) .

Concept maps organise the learning content

The organisation of the core Physical Science concepts is of the utmost importance in designing a concept map for it to be logical and understandable to the learner *"...when there's something that you're not quite sure where it fits, then you can easily look it up, and then you fit it properly in the map...".* A number of authors agree that concept maps are an organisational strategy for ordering concepts within a framework that has meaning for the learner (Ault, 1985:38,41; Okebukola, 1992b:220; Willerman & MacHarg, 1991:707; Edmondson, 1995:778; Fisher, 1990:1009, 1014; Halpern 1992:5).

Uniqueness of concept maps

Concept maps are unique to the learner who designed them

It emerged from the focus group that a concept map is unique to the learner who designed it. The learner determines how his/her concept map will look, because it is designed in such a way that he/she may understand it. The learner gives unique meaning to his/her concept map; it is like a "picture" to him/her. The concept map serves as a meaningful visualisation of his/her knowledge to the learner (Lloyd, 1990:1029; Towbridge & Wandersee, 1994:472; Novak, 1990a:31, 37; Roth, 1994:198). *"...I mean, when I've written my words there I know what it means, but if another person comes and reads it, he's not going to know what I'm thinking if he reads it, so it's not going to work if someone else designs it..."*

Concept maps are pliable in that they may take on any form

The learner determines how his/her concept map will look. Its form, structure and neatness are determined by the learner (Okebukola, 1992a:154; Moreira, 1979:283; Wandersee, 1990:930) Participants concluded: *"... the concept map that you actually make, it doesn't look exactly like the one that you were taught, it's sometimes a bunch of circles and things like that. You can draw a map but it's not to say it will look like that, it can look very different but has the same effect as that map. Your own way, your own type of map, everyone will have his or her own type of map. Some people might have one word and then they understand the whole thing. Some people will write more than one word to understand the whole thing..."*

The ease with which learners design concept maps versus the subject content

Some learning content in Physical Science is more difficult for the learner to incorporate into a concept map. A concept map on potential difference as part of the electricity theme is, for example, "easier" to capture in a concept map than the design and workings of an electric motor. For this reason, learners experience that concept maps are utilised with "difficulty" in certain sections of subject content *"...because the electricity we did was facts, and not long explanations, it was easier to put into a concept map, but I think other things like another topic in Science can be a bit more difficult..."* and *"...other people have other ways, but for me concept maps worked well in electricity ... but with other things like another chapter of Science or with Biology, it just won't work for me, I don't think I'll know how to put those kinds of things together..."*. Lloyd (1990:1029) confirmed this when he said it is easier for learners to draw concept maps for detailed texts than for texts, which have a paucity of information.

Limitations of concept maps

Concept maps are not suitable for lengthy explanation

This finding is related to the previous main category. According to the learners, it appears that certain content in Physical Science, which requires lengthy explanation is not suitable for use in a concept map. The content is of such a nature that it is described more meaningfully as a "story", and that one term may contain such a wealth of meaning that a concept map may be designed for such a term on its own. The holistic picture then suffers as a result, *"your concept map will be so wide in order to explain everything, that it will take so much time and place that it won't be worth it..."* There is no literature reference to support this aspect.

Concept maps impede learning

For a few learners, the use of concept maps in Physical Science is ineffective. If the learner prefers his/her own former learning style, then it is more beneficial to remain with these former learning methods. Such a learner rejects concept maps and is resistant to their use. It is easier for these learners to utilise their former learning methods than to "struggle" with concept maps, *"...I feel the concept maps are harder to learn ... they're more complicated..."* and *"...I think everyone basically has their own learning method, and if you design a concept map and find that it doesn't learn as well as the old method, then you go back and just learn the old way..."*. This is supported in the literature where Lehman **et al.** (1985:670, 672) as well as Willerman and MacHarg (1991:706) state that there is no evidence of definite and incontrovertible proof that concept maps promote learning. Some researchers also view concept maps as a gimmick, which is too vague to be, considered meaningful (Edmondson, 1995:791).

Concept maps are time-consuming and require repetition and revision

Learners ensure that relevant concepts, which are required to master the content of the subject, are included in their concept maps by repeatedly designing and revising them. This is time-consuming. Repetition of design ensures that all the concepts are included, that the relationships between them are correct and that possible errors and misconceptions are ruled out. In the event that this has not been ensured, the concept map is redesigned to ensure that it is as complete as possible, *"...if I make concept maps then I do it so I can understand them, so each time I'll make new concept maps, so that I can see if I understand them or not, because if I don't make one each time, then I don't understand it and then I must learn it again..."*. Effective concept maps usually require a number of reconstructions. As concept maps are reconstructed, the quality and quantity of the notions contained in them, as well as their meanings and usefulness improve (Roth & Roychoudhury, 1993b:240; Moreira, 1979:283; Ault, 1985:41/2; Grant **et al.** 1990:18; Starr & Krajcik, 1990:996-998; Wallace & Mintzes, 1990:1034; Beyerbach & Smith, 1990:963, 969; Shymansky **et al.** 1993:752)

Concept maps contain equal risks of failure as other learning methods

Anxiety or uncertainty about whether the learner will be able to reproduce the Physical Science knowledge is an experience that is integral to the learning processes of many learners. For the focus group learners, both concept maps and other learning methods contain equal risks of failure, namely that the learner will forget important concepts, *"...doesn't matter what kind of summaries you make, you can always leave something out..."* and *"...if you make concept maps, there's no bigger risk of leaving something out than if you just make ordinary summaries..."*. No literature support could be found for this.

The future use of concept maps is uncertain for some learners

The learners are clearly aware of what concept maps are, and even though these maps represent a new learning method, they know how to apply them with familiar learning content. However, the learners are cautious and unsure about whether concept maps may be utilised equally effectively in the future. This hesitancy is also related to feeling unsure about forthcoming new learning content *"...although concept maps are new, new for us, and we haven't experimented* *much with them yet...*" and "*...yes, we know what's going on there, but now this term we have started Chemistry. So we'll have to put what we've done into concept maps, but I don't know, I don't know how it will go ahead...*" There is also no support in the literature for this.

CONCLUSIONS

The purpose of this study was to determine learner experience of concept maps as a method of learning in Physical Science. The general essence of the experience of learners is that concept maps promote learning in Physical Science. In particular, and in support of the general essence, certain advantages to the use of concept maps were identified. Through the exploration of learners' experience of the use of concept maps, definite characteristics of concept maps were identified. Unique learner experiences of concept maps as a learning method in Physical Science, which have not been described in the literature, have emerged in this study. It was mentioned that only some Physical Science content is suitable for the use of concept maps and other content need to be studied through "story telling". For some learners concept maps are not a better method of learning, because all learning methods have the same risks of poor recall of knowledge.

The uniqueness of concept maps was also described in that concept maps are unique to the person who constructs them - somebody else might not be able to use them. Although many positive aspects with regards to the use of concept maps have been described, some limitations of concept maps were identified. Concept maps are not suitable for lengthy explanations, they are time consuming and might impede learning in some instances, but the category which is evident above all is that concept maps promote meaningful learning, and thus this forms the essence of learner experience in this study.

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