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Concept map as an assessment tool in secondary school mathematics: An analysis of teachers' perspectives

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This paper reports on teachers' views on concept mapping: its applicability; reliability; advantages and; difficulties. A close-ended questionnaire was administered to 50 purposefully selected secondary school mathematics teachers from Sekhukhune District, Limpopo, South Africa. The findings indicate that mathematics teachers generally perceive that concept map: is useful; effective; is a practical tool for teaching mathematical concepts; represents and organises knowledge; helps retention and recall of concepts learnt and; provides feedback on the understanding of the concepts learnt. An important implication of this study is that there is a need for teachers to incorporate the concept mapping in the formative assessment process.

Keywords: assessment, perceptions, conceptual understanding, concept mapping.

INTRODUCTION

Assessment is defined as the process of gathering information so as to monitor learners' progress and make sound instructional decisions (Lewis, Madison-Harris, Muoneke, & Times, 2010). Traditionally, mathematics teachers use paper and pencil tests as tools to assess learning. However, this is not the best way to assess learner understanding of mathematical concepts (Rudner & Schafer, 2002). Novak and Canas (2006) advocate the need for better ways to represent learners' conceptual understanding in the form of concept map as an alternative assessment tool.

A concept map is a pedagogical tool that helps learners to structure their learning in useful ways (Ellis, Rudnitsky & Silverstein, 2004). Concept maps are a graphic representation of learners' knowledge. Concept mapping as assessment has two components: a task that learners perform to demonstrate knowledge of a concept and a rubric which a teacher uses to evaluate the learners' knowledge (Stoddart, Abrams, Gasper, & Canaday, 2000). In addition, Ruiz-Primo (2004) describes a concept map-based assessment as consisting of a task that elicits connected understanding, a response format, and a scoring system. Concept mapping has been demonstrated to

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be a powerful instructional tool which assists teachers to assess learners' understanding and make connections between concepts explicitly (Tuan & Thuan, 2011). Having learners create concept maps can provide the teacher with insights into how learners organize and represent knowledge. This can be a useful strategy for assessing the knowledge learners have before engaging in further learning or a new program or course (Hay, Kinchin & Baker, 2008). A concept map is also a valuable tool for demonstrating the changes that occur in a learner's knowledge structure and the increasing complexity of knowledge structure that develops as learners integrate new knowledge with existing knowledge (Vanides, Yin, Tomita, & Ruiz-Primo, 2005). Concept mapping also provides a unique pictorial representation of learner understanding of a concept, problem, or idea (Nesbit, & Adesope, 2006). Varghese (2009) views the use of concept map as an effective way of looking at what is inside the learner's mind and reveals conceptual understanding that are not generally identifiable by other assessment tools such as written tests.

Assessing using concept map can help the teacher to gain insight into the way learners view a mathematical concept and misconceptions learners hold as well as assessing the structural complexity of the relationships learners depict (Nesbit & Adesope, 2006). Teachers can also use concept mapping to organize their ideas in preparation for instruction, as a graphic organizer during class, and as a way to encourage learners to reflect on their own knowledge.

Birgin (2011) also asserts that assessment of mathematics learning remained virtually unchanged throughout most of the last half century. Traditional written tests dominate other forms of assessment (Dogan, 2011). The same idea is accorded with Detweiler (2012) who posits that traditional written tests have contributed to learners pursue for grades rather than conceptual understanding. Elliott, Kettler and Roach (2008) suggest that broadening the spectrum of assessments to include alternative assessments that provide an opportunity for learners to make conceptual connections and reflect on understanding can refocus learners towards the pursuit for understanding.

According to Adlaon (2012), a concept map provides a better gauge of what learners know than most other assessments tools because it allows free response and it provides insights into the learners' knowledge structure. Coon and Mitterer (2012) also found that concept maps also measure aptitudes not commonly assessed by typical objective tests.

Another important benefit of using concept mapping as an assessment method is its ability to detect or illustrate learners' deep content understandings as well as their misconceptions when they create a personal explanation of content matter (Liu & Wang, 2010). According to Grossman, Shoenfeld and Lee (2005) learners can begin to understand the subject matter better and to expose or acknowledge gaps in their conceptual knowledge if conceptual map is incorporated in their learning situations.

State of the literature

- Rudner & Schafer (2002) asserts that teachers think of assessment as pencils and paper. However, assessment can be a task that shows a learner has acquired the concept and can link with other related concepts. According to Ausubel (1968) learning is meaningful when the learner comprehends the relationship of what is being learned to other knowledge.
- Hay, Kinchin and Baker (2008) assert that concept map measures aspects of learning which conventional tests cannot measure such as learners' misconceptions.
- Vodovozov and Raud (2015) argue that a concept map is effective as teaching and learning tool rather than as an assessment tool.

Contribution of this paper to the literature

- There is a dearth in knowledge about how teachers perceive the use of concept map as an alternative form of an assessment in the teaching and learning of mathematics. The qualitative study investigated the thoughts, feelings, and beliefs of teachers about the use of concept map as an assessment tool. The findings of this study shed light on the views that teachers hold about the use of concept map. As such, the findings contribute to or refute Vodovozov and Raud's (2015) argument that a concept map is effective as teaching and learning tool rather than as an assessment tool.

Building true conceptual understanding requires learners to make meaningful connections between mathematical concepts (Liu & Wang, 2010). The teacher can use a concept map as a means of assessing learners' prior knowledge of the topic and monitoring their progress. Concept map supports learners in understanding the novel topics by mapping the links among new and previously studied domains (Vodovozov & Raud, 2015). Concept map can also be used formatively to make learner thinking visible. When learners construct key concepts and their linkages through a concept map, it becomes clear that they understand the main concept around a topic of study. Concept map therefore constitutes sets of procedures that are used to measure the learner's knowledge structure and organization of knowledge in problem solving situations. An explicit characterisation of concept map as an assessment tool was made by Shavelson (2001) who regards concept map as tasks that invites a learner to provide evidence based on his or her knowledge structure, a style that displays how and what a learner learns, and a scoring system by which the learner's conceptual knowledge can be accurately and consistently evaluated.

A further important function of concept map is to provide diagnostic pre-assessment information prior to beginning a unit and formative assessments during learning activities (Llewellyn, 2013). The use of concept map helps in making learners aware of what they do not yet know or understand (i.e., concept knowledge gaps) in a non-judgmental setting and then develop a proactive and positive means for attaining that knowledge (Poling, Goodson-Espy, Dean, Lynch-Davis, & Quickenton, 2015). Kumaran (2015) indicates that concept map develops learners' abilities in certain critical areas such as the ability to draw reasonable inferences from observations, to synthesize and integrate information and ideas and to learn concepts and theories in the subject area. A study conducted by Afamasaga-Fuata'i (2009) shows that the use of concepts helps learners to improve their skills in negotiating meaning, challenging and counter-challenging each other's' explanations. Such findings imply that the use of concept map can facilitate the effective communication of learners' understanding within a social setting.

The main aim of this paper is to report on teachers' perspectives on the effectiveness of concept map as an assessment tool for assessing learners' knowledge structure (or connected understanding).

Problem statement

In mathematics education the term 'assessment' refers to a process of drawing reasonable inferences about what learners know on the basis of evidence derived from observation of what they say, do or make in selected learning situations (Gouli, Gogoulou, & Grigoriadou, 2003). These inferences are drawn mostly from written tests, oral tests, homework and assignments. Hence concept map, as an assessment tool, can be thought of as a set of procedures used to measure important aspects of the structure or organization of a learner's declarative knowledge (Anohina-Naumeca, 2012). Teachers tend to abandon other alternative forms of assessment and concentrate on the written forms (Norton, Harrington, Norton & Shannon, 2006). The use of concept map as an alternative method for assessing learners' knowledge structures lags behind in most secondary schools' curricular world over. Most South African schools rely on assessment characterised by written tests and high-stakes examinations (Department of Education, 2008). Although the use of concept map as an alternative assessment tool has been recognized, teachers continue to use it as an instructional tool rather than as an assessment device (Reyneke, Meyer & Nel, 2010). The study therefore assesses whether teachers view the use of concept map as an alternative assessment tool that can provide reliable and valid measure of learners' knowledge structure.

Research questions

a. What are the teachers' perceptions about the use of concept map as an assessment tool?
b. What are the views held by teachers about assessing using concept map in the learning and teaching of mathematics?
c. What are teachers' beliefs about the use of concept map as an assessment tool that can provide a reliable and valid measure of learners' knowledge structure?

Purpose of the study

This study sought to gain insights into teachers' perspectives about the use of concept map as an alternative form of assessment. The research focused on how teachers view assessment of learners' overall understanding of conceptual structure of mathematics and opinions about learners' abilities to link and relate ideas from various topics in the form of a conceptual map. Although some of the studies support concept mapping as a teaching and learning strategy, they mainly focus on the use of concept mapping as a tool to investigate learner understanding rather than as an assessment tool. Therefore, the purpose of the study was to investigate the thoughts, feelings, and beliefs of teachers about the use of concept map as an assessment tool.

Significance of the study

There is a dearth in knowledge about how teachers perceive the use of concept map as an alternative form of an assessment in the teaching and learning of mathematics. The findings of this study will shed light on the views that teachers hold about the use of concept map as alternative assessment tool. The knowledge of teachers' views about the use of concept map as an assessment helps to offer an explanation of the absence or presence of this increasingly popular tool as at teaching and learning tool or as an assessment tool.

Conceptual framework

The theory underlying the use of concept map as an assessment tool draws largely from Ausubel's assimilation theory (Ausubel, 1968) and subsequent works by Novak and Novak and Gowin (2006). Assimilation theory states that memory is hierarchical and new information is processed and stored into the existing structure (Croasdell, Freeman, & Urbaczewski, 2003). According to Ausubel (1968), the most important factor influencing learning is the learners' prior knowledge. Meaningful learning has the power to generate changes in the cognitive structure of learners, changing prior conceptions and establishing new links between the concepts. Ausubel hypothesised that learning is crucially dependent upon the learner's pre-existing awareness of concepts and their inter-relationships. The theory is consistent with constructivist epistemology (Edmondson, 2000). The constructivist perspective views learning as an active process in which the learner is constantly creating and revising his or her internal representation of knowledge. This occurs when new concepts are linked to familiar concepts existing in the learner's cognitive structure. The constructivist model has been widely accepted as the ideal model for conceptual understanding (Kinnear, 1994). Learners' conceptual understanding is influenced by the prior knowledge they bring to the learning situations. This prior knowledge is labelled as preconceptions, naive theories, alternative frameworks or misconceptions. For constructivism, goals of instruction are deep understanding. The theory stresses that meaningful learning is an effortful process involving the construction of relationships between the learner's existing knowledge and new knowledge. Subsumption is the central idea running through Ausubel's learning theory. The theory claims that meaningful learning occurs when new information is subsumed into a large structure

which relates it to other concepts. According to Ausubel, knowledge can be viewed as an integrated system in which ideas are linked together in an orderly fashion. The theory further claims that the learner's existing knowledge often contains deeply rooted misconceptions that make new learning difficult. The use of concept map holds premise in that it makes issues of knowledge, knowledge structure, and the way ideas are related easy to understand.

METHODOLOGY

This is a qualitative case-study research, which uses an inductive inquiry strategy of approaching a setting without pre-extant assumptions. It involves an intensive analysis of an individual unit (e.g., a person, group, or event) stressing developmental factors in relation to context (Flyvbjerg, 2006). The case study research aims to explore an issue in a bound context or setting, using one or more cases within this context (Creswell, 2007). Thus, the case study is suitable for investigating the central phenomenon of this study: to understand the perspectives that secondary school mathematics teachers hold about the use of concept map as an assessment tool. A case study is an ideal choice for researchers who want to intensively and deeply examine an issue (Creswell, 2007).

Participants

The target population for this study consists of mathematics teachers in secondary schools around Polokwane, South Africa. Using expert sampling, fifty (50) secondary school mathematics teachers (with known experience and expertise in mathematics teaching and assessment) were drawn from 17 public schools to participate in the study. Thirty-one (62%) participants had more than 20 years of teaching experience while 19 (38%) had teaching experience ranging from 5- 20 years. Thirty- three (66%) of the participants were males while seventeen (34%) were females. The schools were chosen because of their accessibility as well as their interest to participate in the study.

Instrumentation

The data for this study were collected using a questionnaire. The questionnaire utilised a Likert scale which was developed to elicit teachers' views on concept mapping, its applicability, reliability, advantages and difficulties. The questionnaire consists of sections A and B. Section A collects teachers' biographic information and Section B have close-ended questions consisting Likert scale with 5 possible responses per item (Maree & Pieterson, 2007): (1) strongly disagree, (2) disagree, (3) unsure, (4) agree and (5) strongly agree. The close-ended questions in the questionnaire were checked by mathematics education experts. The Content Validity Index (CVI) was calculated using the formula below (Polit, Beck & Owen, 2007):

$$CVI = \frac{Number\ of\ items\ judged\ by\ both\ judges\ as\ right}{Total\ number\ of\ items\ in\ the\ questionnaire}$$

CVI for the questionnaire was 0.83. Therefore, the questionnaire was considered valid. In order to ensure internal consistency of the questionnaire, the instrument was piloted to ten mathematics teachers with an educational background similar to that of the study sample. A Cronbach alpha coefficient ($\propto$) was computed from the results using the formula below (Tavakol & Dennick, 2011):

$$\propto = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum S_i^2}{S^2{}_{sum}}\right)$$

Where:

K= number of components (K- Items);

S_i^2 = variance of K individual items;
$S^2{}_{sum}$ = variance for the sum of all items.

Cronbach alpha coefficients were obtained for each item. Any item with a coefficient less than 0.70 was not included in the instrument. An overall Cronbach alpha coefficient ($\propto$) value of 0.85 was obtained for the questionnaire, representing moderate reliability.

Data collection

Data were collected by administering the questionnaire and the return rate was 100%.

Data analysis

The analysis of data for this paper was guided by the framework suggested by Miles and Al- (1994). Descriptive statistics were used to represent data from the questionnaire (Gall, Gall & Borg, 2007). The collected data were analysed using SPSS version 22 and Microsoft Excel. Percentages were used to indicate the frequency of various responses expressed by the respondents. Data were illustrated using tables in order to show the key features of the data in a more compact and interpretable manner.

Ethical considerations

Permission to conduct the research in the schools was sought and granted by the Limpopo Education Department. During the process of data collection and processing anonymity and confidentiality were assured.

RESULTS AND DISCUSSION

The responses given to each close-ended question were grouped thematically according to frequency of occurring. The data are presented in tables showing frequencies and percentages for the participants' responses to the questions.

Teachers (74%) indicated that the use of concept map as a form of assessment is an effective teaching and learning assessment tool (see Table 1). These findings are consistent with the observations made by Vodovozov and Raud (2015). Teachers (68%) also concurred that the use of concept map is a good way of assessing learners' retention of learned concepts (see Table 1). Similar results were reported by Vitulli,

Table 1. What do you think about the use of concept mapping as an assessment tool?

Teacher perceptions	Disagree	Neutral	Agree
Concept map helps to assess learners' retention of learned concepts	8(16%)	8(16%)	34(68%) **
Concept map is an effective teaching/ learning/ assessment tool.	5(10%)	8(16%)	37(74%) ***
Concept map facilitates learning.	13(26%)	13(26%)	24(48%)
Concept map helps to assess learners' ability to create relationships among concepts.	6(12%)	16(32%)	28(56%)
Concept map as an assessment tool is suitable for 8th - 12th grades.	22(44%)	11(22%)	17(34%)
Concept map allows the teacher to visualise learners' knowledge of concepts	7(14%)	11(22%)	32(64%)
Concept map is a useful assessment and evaluation tool for mathematics	18(36%)	6(12%)	26(52%)
Concept map helps the teacher to identify misconceptions in learners' thinking.	12(24%)	8(16%)	30(60%)
Concept map is not suitable for assessment.	15(30%)	5(10%)	30(60%)
Concept map is a useful/necessary/effective technique for assessing learning.	17(34%)	7(14%)	26(52%)
Concept map is useful for measuring learners' knowledge growth after instruction.	11(22%)	6(12%)	33(66%)*
Concept map measures learners' connected and hierarchical understanding of concepts.	12(24%)	81(6%)	30(60%)

Table 2. Do you find assessing using concept map applicable in the learning & teaching of mathematics?

Teacher perceptions	Disagree	Neutral	Agree
A concept map is a useful method of assessing learners' conceptual understanding.	15(30%)	5(10%)	30(60%)
Concept map can be used to evaluate teaching.	17(34%)	7(14%)	26(52%)
Concept map is a useful method to determine prior-knowledge before engaging learners in a new topic.	10(20%)	6(12%)	34(68%) **
Assessing using concept map requires thorough preparation.	12(24%)	8(16%)	30(60%)
Concept map is used in a classroom as alternate assessment technique.	9(18%)	8(16%)	33(66%) **
The use of concept map adds to the range of evaluation practices in current use, which encourage meaningful learning	5(10%)	5(10%)	40(80%) ***
Concept mapping is a valuable formative assessment that provides substantial benefits to learners, in terms of motivation and critical thinking skills.	27(54%)	9(18%)	14(28%)
Concept map enables teachers to understand learners' contexts by generating the identification and analysis of errors.	6(12%)	16(32%)	28(56%)

Giles & Shaw (2014). Another dominant belief held by teachers (66%) about concept map is that they are an effective method of measuring learners' knowledge growth after instruction.

The second research question sought to investigate whether the teachers find concept map applicable in the teaching and learning of mathematics. Table 2 presents frequencies of teachers' responses to statements that were generated from this research question. Forty (80%) of the participants indicated that the use of concept map adds to the range of evaluation practices in current use, which encourage meaningful learning. The findings are consistent with Kilic, Keleş and Sağlam (2012) who indicated that concept map helps to broaden the range of evaluation practices in current use. The majority (68%) of the participants also subscribed to the notion that concept map is a useful method of determining learners' prior-knowledge before engaging them in a new topic. Research has shown that a learner's prior knowledge often confounds teacher's best efforts to deliver ideas accurately (Ford, 2004). Learning proceeds primarily from prior knowledge, and only secondarily from the presented materials (Hung and Khine, 2006). However, participants (54%) opposed the view that concept mapping is a valuable formative assessment that provides substantial benefits to learners, in terms of motivation and critical thinking skills.

The third research question sought to solicit teachers' views about the reliability and validity of learners' knowledge structure and thinking measured using concept map. The teachers (74%) indicated that the use of concept map is an effective way of identifying the relevant knowledge a learner possesses before or after instruction. The same observations were made by Novak and Canas (2007) who argued that concept map is a powerful evaluation tool which encourages learners to use meaningful-mode learning patterns. The majority (60%) of the teachers indicated that concept map is not a useful tool to assist in evaluating end-of-course assessments and cannot be used as a substitute for examinations. Teachers further indicated that concept map is not comparable to traditional examinations and cannot be used as a complimentary summative assessment method. They argued that concept map cannot be used for summative assessment to determine learner understanding of certain content and to assign grades. These findings are consistent with Butler (2014) who argued that concept map cannot be used as a testing method but rather as a teaching and learning strategy.

A request was made from one of the participants to elucidate how he would assess learners' understanding of solving trigonometric equations using concept map. The

Table 3. Do you think a concept mapping can provide reliable and valid measure of learners' knowledge structure?

Teacher perceptions	Disagree	Neutral	Agree
Concept map helps teachers to know how learners are assimilating the content of the course.	16(30%)	4(10%)	30(60%)*
Concept map provides the teacher with a snapshot of learner knowledge and understanding.	18(34%)	7(14%)	25(50%)
Concept map helps teachers to clear up any misconceptions and misunderstandings.	11(22%)	8(16%)	21(42%)
Concept map is a useful tool to assist in evaluating end-of-course assessments, complementing or even replacing the exam.	30(60%)*	8(16%)	12(24%)
Concept map is also effective in identifying both valid and invalid ideas held by learners.	7(14%)	8(16%)	35(70%)*
Concept map is an effective way of identifying the relevant knowledge a learner possesses before or after instruction.	5(10%)	8(16%)	37(74%)*
The scoring systems for concept map closely correlates with traditional testing scores	28(56%)	7(14%)	15(30%)
Concept map is comparable to traditional exams and should be used as a complimentary method of assessment.	37(74%) **	6(12%)	7(14%)
Concept map promotes frequent and high quality feedback that activates the cognitive and meta-cognitive processes of learners,	13(26%)	13(26%)	24(48%)

teacher would first instruct learners to identify relevant ideas and concepts that can be incorporated when solving each trigonometric equation given. The following example will elucidate how some of the teachers are using concept map as a measure of learners' knowledge structure.

Find the general solution of the trigonometric equation: $sin^2\theta - cos\,2\theta - 8\,sin\,\theta - 2 = 0$

The learners are expected to do the following:

Step	Concept identified
$\sin^2\theta - \cos 2\theta - 8\sin\theta - 2 = 0$	Quadratic trigonometrical equation
$\sin^2\theta - (1 - 2\sin^2\theta) - 8\sin\theta - 2 = 0$	Double angle identity ($cos2\theta = 1 - 2sin^2\theta$).
$\sin^2\theta - 1 + 2\sin^2\theta - 8\sin\theta - 2 = 0$	Multiplication by a negative sign.
$\sin^2\theta + 2\sin^2\theta - 8\sin\theta - 2 - 1 = 0$	Grouping like terms.
$3\sin^2\theta - 8\sin\theta - 3 = 0$	Combining like terms (quadratic equation in $\sin\theta$).
Let x = $\sin\theta$, then $3x^2 - 8x - 3 = 0$	Standard quadratic equation in x.
$(3x+1)(x-3) = 0$	Factorising the left side.
$3x + 1 = 0$ or $x - 3 = 0$	The Zero product rule.
$x = \frac{-1}{3}$ or $x = 3$	Solving linear equations (solution of quadratic equation in x).
$\sin\theta = \frac{-1}{3}$ or $\sin\theta = 3$ (n/a)	Reverting to the original equation variable; $\sin\theta$ is a bounded function ($-1 \leq \sin\theta \leq 1$).
$\theta = \sin^{-1}(\frac{-1}{3}) + 360k$, or	General solutions, quadrants, reference angle, integers, inverse functions, revolutions, period,
$\theta = [180 - \sin^{-1}(\frac{-1}{3})] + 360k,\ k \in \mathbb{Z}$	

At the end of the lessons concerned with the solution of trigonometric equations, the teacher asks learners to generate a concept map in relation to solving trigonometric equations. The concept map below provides a summary of the different

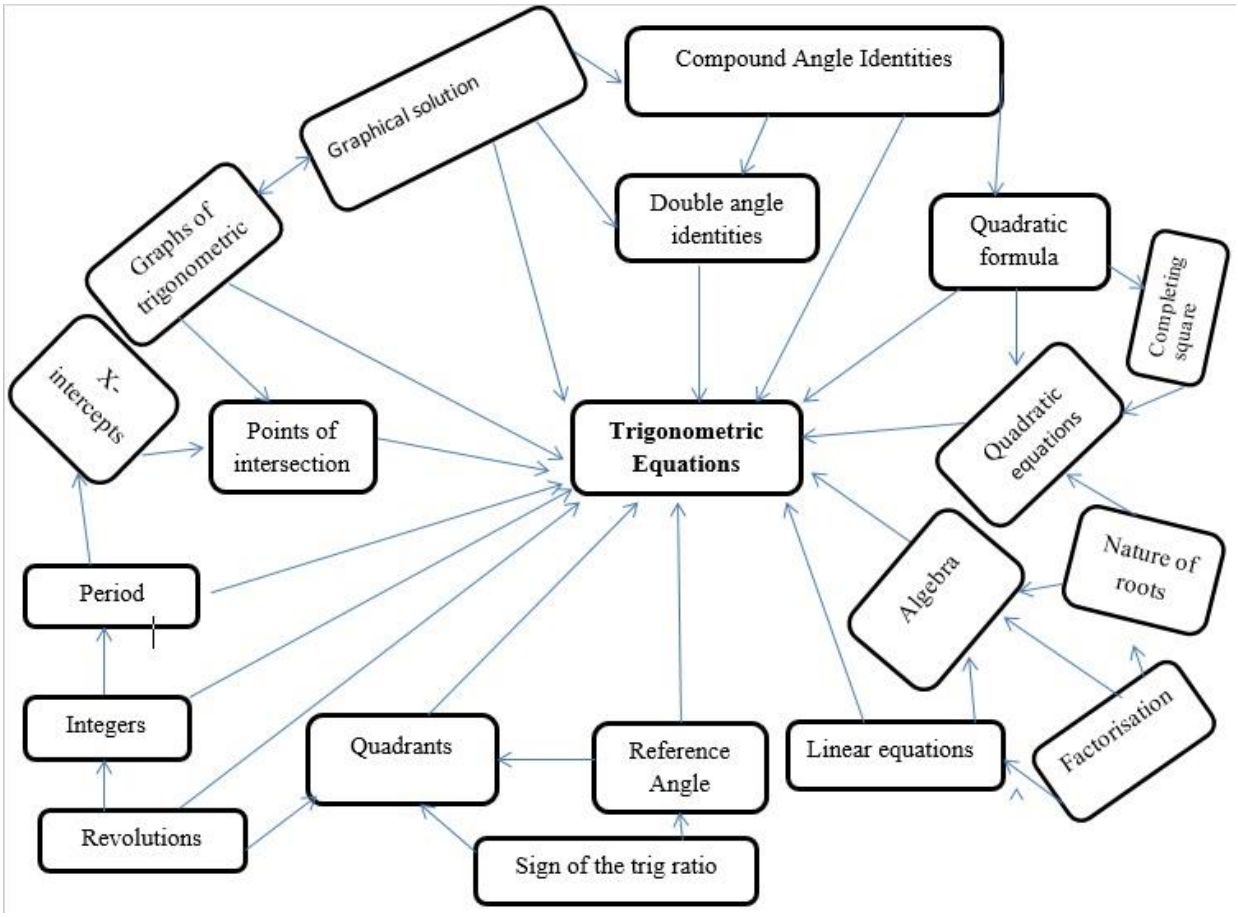

Figure 1. Concept map for solving trigonometric equations

concepts that can be generated by the learners as they solve different types of trigonometric equations using the approach above (See Figure 1).

The idea is to assess if learners can produce visual representations of ideas and concepts and effectively incorporate them when solving trigonometric equations. Learners will be assessed on how they organise their knowledge of solving trigonometric equations as well as establishing how they understand concepts related to trigonometric equations such as quadratic equations, the nature of roots, different solution methods, and algebraic processes such as factorisation, completing the square and the use of different number systems. Thus the number of linkages in a network of concepts tells the teacher much about the meaning of the concept from the perspective of the learner.

Furthermore, an analysis of learners' written work and conceptual maps done at the end of the lessons concerned with the solution of trigonometric equations indicated that most learners associated trigonometric equations with identities, quadratic and linear equations. In addition, in solving quadratic trigonometric equations, learners converted the equation to a quadratic with variable x since they were familiar with quadratic equation in terms of x. The connection of k to integers was not a common feature since learners could not link revolutions to integers. Thus, this could be a possible explanation as to why most learners struggled with the general solution of a trigonometric equation. Insufficient knowledge about periodic functions was also observed as learners struggled to find other solutions to the equation after obtaining the reference angles. The graphical method was rarely used while the use of the quadratic formula and factorisation was dominant. Knowledge of the graph of the *sine* function was also another useful concept since it helps learners to determine whether the solutions to linear equations exist.

CONCLUSION

Results of this study indicated that secondary school teachers generally perceive concept map as a useful and effective assessment tool. Teachers also concurred that the use of concept map is good way of assessing learners' retention of learned concepts. Furthermore, they highlighted that concept map provides a quick snap-shot of learners' prior knowledge before engaging them in the teaching and learning process. Participants also expressed that concept map is appropriate at the end of the lesson to provide formative feedback. However, participants were strongly opposed to the use of concept map for assigning final grades in a learning area, arguing that it is suitable for assessment of learning rather than assessment for learning. Generally, the emerging consensus among participants regarding concept map is the use of concept mapping as learning, teaching and evaluating tool by teachers during the instructional process. Participants also subscribe to the notion that concept map provides informative and reflective feedbacks tailored to learners' personal abilities. This information helps teachers to plan instructional experiences aligned to learners' traits. Finally, teachers expressed discontentment over the use of concept map as a possible replacement to traditional examination. It can therefore be concluded that participants regard concept map as valuable for formative rather than summative assessment.

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