Inventive mathematics teaching practices using learner-centred to teach mathematical operations of fractions in the Zambezi Region

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Abstract
Various factors are associated with high failure rate witnessed in mathematics in Namibian schools. Some of these factors which researchers, policy makers, teachers and learners suggest are; (a) Teaching strategies; (b) Content knowledge and understanding; (c) Motivation and interest; (d) Laboratory usage; and (e) Syllabus non-completion and many more which might be resource or system related. To address some of these factors, innovative mathematics practices are encouraged in the teaching of mathematics in Namibian schools. These innovations are manifested in the use of learner-centred approach in mathematics teachers' practices. To gain insight on strategies teachers use to teach mathematical operations; addition, subtraction, multiplication and division of fractions, and the content knowledge teachers pose to teach operations of fractions, innovative mathematics teaching practices using learner-centred methods were investigated.

To answer the research question posed, in order to gain insight into inventive mathematics teaching practices using learner-centred to teach mathematical operations of fraction in the Zambezi Region, this qualitative study used document analysis, interviews and observations. To support the data yielded, which can be recommended to others, the study looked into fractions and how they are taught and possible ways to transform the current practice. The constructs learner-centred, traditional and modern methods of teaching fractions, cognitive and social constructivist as theoretical frameworks were discussed. Some of the findings were; teachers lacked fraction content knowledge and they did not engage habits of mind to ensure that their approaches adopted learner-centred teaching.

Keywords: *learner-centred, innovative, habits of mind, basic operations*

Introduction and background

The learning of mathematics was optional in Namibia before the reviewed curriculum was implemented (Angula, 2015). A learner after grade ten was allowed to drop mathematics and opt for subjects he/she felt comfortable with. This paved a way for the majority of learners to abandon the learning of mathematics that is a useful tool in all subjects and any other human cultural activities (Attard, 2014). The viewing of mathematics as a useful tool in Namibia surfaced soon after independence when mathematics was made a compulsory subject by the current SWAPO government. Mathematics was made compulsory up to grade twelve but before it was compulsory up to grade ten. Even though this decision was reached a large number of learners had already built a view that mathematics was a challenging subject. This has led to mathematics learnt by fewer learners. Some in their careers might have managed to train as mathematics teachers even though some might not have done mathematics up to grade twelve. The majority who did not do mathematics up to grade twelve sometimes went through some various courses with private institutions and then finally got a post as lower primary school teacher where mathematics as a tool is needed to build number sense concepts which Faulkner (2009) considers pivotal for mathematics understanding in other situations in daily life. To upgrade their mathematics skills these teachers enrolled with University of Namibia to gain more understanding in the teaching of lower primary phase.

As a mathematics educator involved in supporting these teachers it aroused my interest to find out the content knowledge these teachers pose that enables or constrains the teaching of mathematical operations; *addition, subtraction, multiplication and division* of fractions and what are the teaching strategies involved when they teach these operations. The Namibian mathematics teachers' lack of subject content knowledge in fractions at the primary school level and their operations is not manifested by them only. Faulkner (2009) reports the same phenomenon observed in the United States of America. He revealed that qualitative studies done show that elementary mathematics teachers tend to lack a "profound understanding" of the fundamentals of the mathematics they teach. The importance of gaining insight into the stated research questions might help in improving teachers' strategies in dealing with operations involving fractions, their content knowledge of fractions and thereafter improve the mathematics pass rate. The experience was gained when visiting trainee teachers on school based studies (SBS). Several times after observing the trainee teachers I checked learners' books to see how they assess and comment in the workbooks but I never saw where an invented mathematics teaching strategies (IMTLS) was used. Cuoco, Goldenberg and Mark (1996) encourage developing habits of mind in learners and invent is one. This justify why we came with the idea of IMTLS. This led to have the problem which this study aims to address to be expressed as in the paragraph which follows.

Statement of the problem

While on SBS, observing trainee teachers teaching mathematics to primary school learners, some challenges were observed. After learners were given a test where some of the concepts were based on fractions, the majority of the learners in lower primary phase did not make it. This aroused our interest to find how the concept of fractions and operations were answered in answer sheets of fifty eight learners. Questions on fractions in the test paper were analysed to support this study. The aim was to find out how these teachers solved the questions related to fractions. The results emerging from the analysis was not impressive as Figure 1 reveals. This paved the way to find out how concepts of fractions are taught in lower primary classes while engaging learner-centred approach.

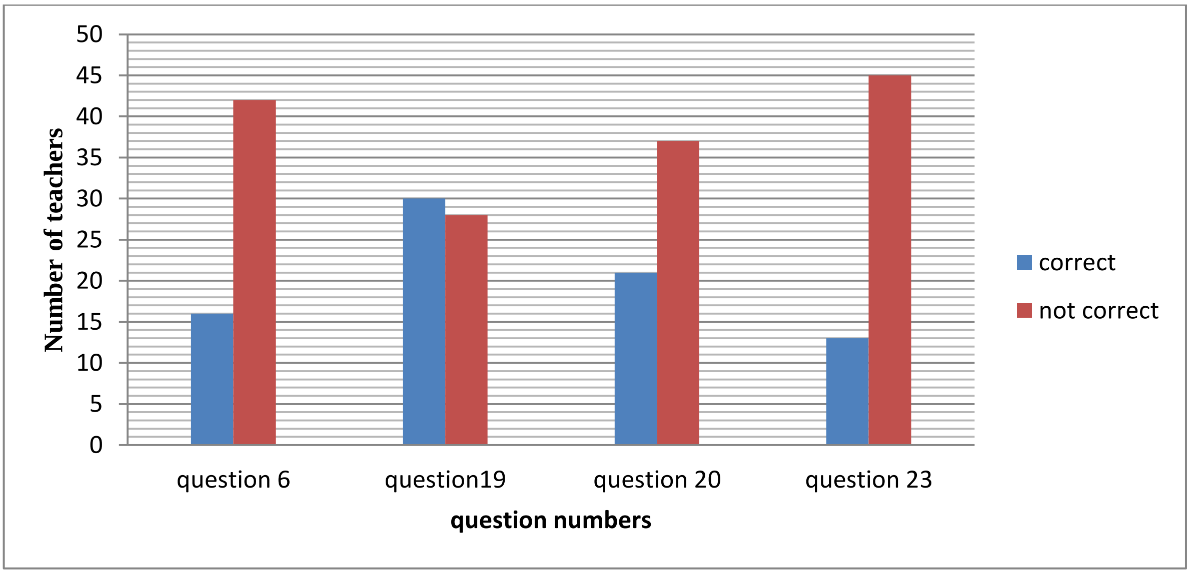

Figure 1: Performance of teachers on questions related to the concept of fractions and their operation

In Figure 1, question 6, 20 and 23 reveal that the grade three mathematics learners who wrote the paper had very low scores. Most of them did not manage to get those questions correct. Even though the trend in question 19 changed it still does not give a good picture. Those who managed to score correct marks were almost equal to those who failed to get the question correct.

In the curriculum documents, the concept of fractions shows conceptual cohesion and progression (Kriek & Basson, 2008). That is, concepts are introduced in Pre-primary and then are revisited in the next grade but each concept is at a higher level of the rung. Each time the concepts are revisited, the ideas gained in lower grades serve as prior knowledge for the same concepts being introduced by the teacher. Failure of teachers to teach the concept of fraction and their mathematical operations; addition, subtraction, multiplication and division using what the curriculum recommends, learner-centred approach, is one of the factors contributing to high failure rate in mathematics. This is manifested when learners write national examinations. According to Mateya, Utete, and Illukena (2016) suggest that some of the factors; researchers, policy makers, teachers and learners mention include; (a) Teaching strategies; (b) Content knowledge and understanding; (c) Motivation and interest; (d) Laboratory usage; and (e) Syllabus non-completion and many others which might be resource or system related.

This study focused on teaching strategies these teachers used to teach fractions and also investigated the fraction content knowledge and understanding the teachers possessed. To understand how operations of fraction were taught in the Zambezi Region.

Conceptual frameworks

A conceptual framework is a synthesis of the existing views in the literature concerning a given situation (Imenda, 2014). Liehr and Smith (1999) suggest that a conceptual framework is a model or integrated way of looking at a problem. In this study, the conceptual frameworks were the traditional mathematics teaching and learning strategies (TMTLS) which are generally teacher-directed and where students are taught passively (Tularm, 2018). However, opponents to TMTLS claim that the invented mathematics teaching strategies (IMTLS) are encouraging developing of habits of mind (Cuocco, Goldenberg & Mark, 1996) bring about learner-centred (LC).

Traditional mathematics teaching and learning approach (TMTL)

Teachers whose worldview is behaviourist according to Karten (2009) entertain the idea that learners respond to stimuli in their environment and teachers' responsibility is to provide necessary and useful stimuli. Also, behaviourists believe that there are some learners with a talent to learn mathematics. This is in sharp contrast to Chambliss (1989) who views a talent as a social construct. Chambliss (1989) asserts that there is no one born with a talent but through practice one constructs and gains mathematics knowledge to excel. Behaviourist teachers use an approach in which initiation-response-evaluation (IRE) are dominant (Mehan, 1979).

According to Mehan (1979) also supported by Wang (2014) a mathematics teacher initiates the conversation. In most cases the teachers present known facts about the concept under study. For example when dealing with fraction operations involving division, which is sharing, the teacher presents on the board how the parts in the problem are dealt with using mathematical symbols representing the mathematical language of terms under consideration. Thereafter, the teacher expects that the learners have been drilled enough to work another example which will have the same pattern. He pauses for the learners to give a response. The learners are expected to follow the same steps like what he had done. When he sees that sufficient time for pausing has been given to the learners he starts his evaluation. In his evaluation the teacher ensures that learners have followed all the steps like what he did in the examples he had presented. Sometimes those learners who would have given a response using their inverted methods are reprimanded. This allows the teacher to adhere to his TMTL approach. For example in the case of a problem on mean and also involving fractions, the question might be:

Four learners, Mary, Peter, John and Jane had their bags searched. Mary's bag had 4 pencils, Peter's bag had 3 pencils, John's bag had 5 pencils and Jane's bag had 6 pencils. Find the mean. One of the learners might have not used the long division to arrive at getting the value of the mean. Instead he might have worked the question as follows:

To calculate the mean one learner proceeded as follows:

Mary Peter John Jane

+ 1/4+1/4
= 4½

+1/4+1/4
=4½

+1/4+1/4
=4½

+1/4+1/4
=4½

∴ Mean = 4½

Sometimes such a learner who resorted to using an inverted method is reprimanded. The teacher believes it is good to drill the learner. The particular learner sees finding the mean as sharing objects equally. To share the remainder the learner first divided each remaining pencil into four parts, gave each out and repeated the process. He found that the two 1/4 each member receives will add up to 1/2. The total for each yield is 4½.

In cases where the teacher uses questions to initiate, pause for response and then evaluate, this does not allow a learner to participate cognitively as he constructs maths knowledge. The classroom talk is teacher-centred and resonates well with the behaviourist worldview. This restricts the learners from developing their mathematical language and conceptual development is hampered. If one's language of mathematics is not developed then the habits of mind are weak.

Habits of mind are dispositions or skills learners need to have in order to understand mathematics concepts. There "is no one correct or complete list of mathematical habits of mind" (Seeley, 2014, p. 248). Some of the habits of mind Cuoco, Goldeberg, and Mark (1996) propose enable learners to; sniff out patterns, create, invent, conjecture, experiment, describe, tinker, visualize and guess.

Weakened habits of mind mean that mathematics is still viewed using the same lens used in its ontogenesis. However, it is important that the use of other lenses foster better understanding. A better understanding entails that better models to represent mathematical concepts come from learners. That is mathematics learners do not just copy what already exists but as learners who might be pushed to work nearer to the level of the real mathematician, they will be like any mathematician who brings new mathematics ideas in a community of practice (Lave & Wenger, 1991).

Even though TMTL anchored on behaviourism is limited since power and control is invested in teachers, it leads to non-cognitive participation of learners. Also, TMTL limits learners to use strategies which the teacher employed during classroom discussion. On the other hand, the RMTLS to be discussed below encourages learners to participate physically or cognitively in Mathematics. The RMTL anchored on constructivism is compatible with other theories of teaching and learning as will also be seen in the section which follows.

The reformed mathematics teaching and learning approach (RMTL)

The RMTL is responsive to the current theories of teaching and learning namely constructivism and all its strands. The teachers engage learners and this facilitates the emerging of arguments. As the learners argue they develop their mathematical language during classroom talk (Lemke, 1990; Krajcik & Sutherland, 2010). A cognitive conversational or inquiry based approach allows learners' mathematical creativity to develop. Furthermore, more strategies can be created which favour learner-centred approach and some of these strategies which are inquiry based favour learner-centred. The learner-centred (LC) approach is used in Namibia and other Sub-Saharan African countries. The LC approach favours the RMTL and is suitable for coming up with strategies to teach operations as discussed below.

Use of learner-centred strategy to support RMTL

According to Weimer (2002) learner-centred approach is anchored on ensuring that classroom power is shifted to learners to foster active learning. LC encourages critical thinking among learners. The teacher ceases to be an authority. Also, in the LC approach learners take part in directing their knowledge and employing effective assessment that inform future practices.

Sibuku (1997) points out that Namibian government after gaining political power overhauled the apartheid education system which entertained TMTLS only. The aim was to align teaching approaches that embrace LC with social theories of teaching and learning in line with the *Harambee* prosperity plan. Nakale (2016) suggests creative conducive conditions. According to Nakale (2016), *Harambee* construct reflects the *Unhu*/*Ubuntu* worldview to flourish which encourage teaching and learning in Namibia not to privilege cognitive theories which do not allow learners to contribute while using their cultural resources but embrace social theories. The IMTLS in which LC features replaced behaviourists' theories. However, to ensure that the tenets of LC Weimer (2002) mentions are engaged, the teachers view is that this requires teaching resources. Sibuku (1997) in support states that trainee teachers sometimes fail to engage learner-centred approach on account of lack of facilities and basic materials.

This is true that resources need to be in place. Faced with the large number of schools which the Namibian government supplies educational materials to, sometimes makes it difficult to ensure that every school has the required materials. Sometimes in under-resourced schools the teaching and learning material are not there. Schweisfurth (2011) also is in support of Sibuku (1997) by pointing out that LC implementation is riddled with stories of failure attributed to lack of materials. Gaining of political power does not imply a nation has the economic kit or credentials to finance the buying of teaching resources for all schools. In view of the identified challenges how can maths teachers ensure that practices in operation of fractions are LC compliant?

One of the benefits of adopting the RMTL approach is its compatibility with learner-centred. LC entails that teachers teach students how to think, solve problems, use the four "Es" namely; engage, explore, elaborate and evaluate evidence. This resonates with the characteristics of constructivist theory of teaching and learning. Learner-centred teachers work to develop mediating practices that promote shared commitments to learning. Mediating tools such as models, case studies, iconic, practical activities, patterns and vocabulary which Conole (2008) suggests allow teachers to present operations of fractions using concrete procedures. This study investigated how the use of area model can be used to ensure that operations of fractions are taught using LC approach. Relating the concepts of fractions and their operations to area model sometimes does not only prevent the mathematics concepts to be inert (Hale, 2013), but also allows the teacher to culturally contextualize teaching and learning as the examples they might use might possibly come from the community of the learners even if learners are from heterogeneous cultural groups. That is RMTL comes with culturally responsive pedagogical styles.

Learner-centred used in IMTL encourages learners to develop the mathematics vocabulary through conversations or arguments as we have suggested above. Sometimes teachers and learners on account of using English as a language of teaching and learning which is not properly understood (It is their second language) can start from analysing patterns of geometrical shapes to be used in area model to represent fractions which are in a learners' community. As they come to know what a pattern and geometrical shape are they can then relate them to analyse patterns of area in mathematical expressions representing operations. This will then help them solve operations of fraction since they would have understood the meaning of the term pattern.

The use of IMTL through embracing LC does not only address pedagogical styles as we have explained above or curricular inadequacy but it also addresses the goals of education in Namibia namely; equity, democracy, quality and access. The need to adhere to the tenets of LC compels mathematics teachers in under-resourced schools to search and relate mathematical practical activities which engage learners' cognitive system.

Another benefit of employing area model to engage LC is the habits of mind mentioned in previous section are developed. This then consolidate the idea that mathematics is dynamic as new ideas will not only come from the teacher who is viewed as the central figure in TMTL. The four "Es" we have mentioned allows the learners to be sniffers of patterns, creators, inventors, conjecturers, experimenters, describers, tinkerers, visualizers and guessers as they come with equivalent fractions needed in addition to fractions with different denominators using invented methods. To investigate how operations of fraction are taught in the Zambezi Region the following research questions were asked.

Research questions

1. Which teaching strategies do teachers use to teach operations of fractions?
2. Are the mathematics teachers in possession of fraction content knowledge needed to teach fractions?

Methodology

To answer the stated questions this qualitative and interpretive study was supported by cognitive constructivism. The study was conducted in two schools in the Zambezi Region of Namibia. In each of the schools which were selected purposefully twenty learners were observed. Purposeful sampling was done in order to select four mathematics teachers whose characteristics matched those described in the background of this study. This was aimed at gaining insight into the strategies teachers use to teach fractions and their mathematical operations. Ten learners from each of the two different grades, three and six participated. One was a lower primary class and the other was an upper primary class. This was the same with the other school. This allowed seeing the strategies used to introduce fraction concepts in lower primary classes and to see the strategies used in upper primary classes.

The twenty learners who were the participants were initially observed while they were being taught fractions and mathematical operations in fractions. This was aimed at addressing research question 1 that was aimed at understanding the teaching strategies teachers used to teach operations of fractions. Thereafter, twenty learners were involved in the use of area model in understanding fractions and their operations. The use of area model acted as the intervention which saw the learners actively participating in using algorithms that used the area model to solve problems related to fractions and operations of fractions. The intervention, which took two weeks, was necessary to empower teachers to use IMTL methods

To validate data yielded from observations, document analysis of learners' worksheets was carried out. This was aimed at finding the emphases the curriculum material had on the teaching of fractions. This allowed to emerging the subject content knowledge that the teachers are supposed to have in order to be able to teach the concept of fractions to the learners. One observations done in each of the four classes also aimed to assist in finding an intervention suitable which enabled teachers to move from the TMTL to RMTL. When an intervention was in place, learners were supported by researchers and the participating teachers to answer questions involving operation of fractions using area model. Worksheets where learners did their task which they were given by the teacher using TMTL were collected and analysed. Also worksheets they used to solve fraction problems using area model were collected for further analysis. Thereafter, learners were asked to answer interview questions conducted by the researchers. The lower primary learners were questioned using their first language. The responses were transcribed then translated into English. The use of the instruments allowed triangulation and validation to be done. The data which emerged from worksheet analysis is presented below.

Data presentation and analysis

Data that emerged through the use of document analysis, observation and interviews are presented below. The data yielded were found to answer the research questions, which was selected and presented. This was done in order to respond to the research questions.

Data from document analysis and its analysis

The syllabus for lower primary analysed indicated that mathematics teachers should introduce fraction concepts using area model (Namibia Ministry of Education, 2015). This is evident since in the syllabus, the discussion of fraction concepts is accompanied with area model diagrams to explain what is 1/2; 1/4; 1/3 and a whole. Besides using area model, the diagrams which the syllabus use or illustrate for teaching the concept of fractions are those which the learners know very well. For example, a glass used for drinking liquids is presented with 1/2 amount of water and then it is also presented full of water. A glass of water is cultural artefact seen in the community of the learner which can make the concepts of fraction not appear abstract if used.

The upper primary learners were given a task to do after the teacher completed the teaching of fractions and their operations. The questions in which concepts of fractions and their operations were asked were analysed in the answer scripts from the learners. Figure 2 represents how these learners performed.

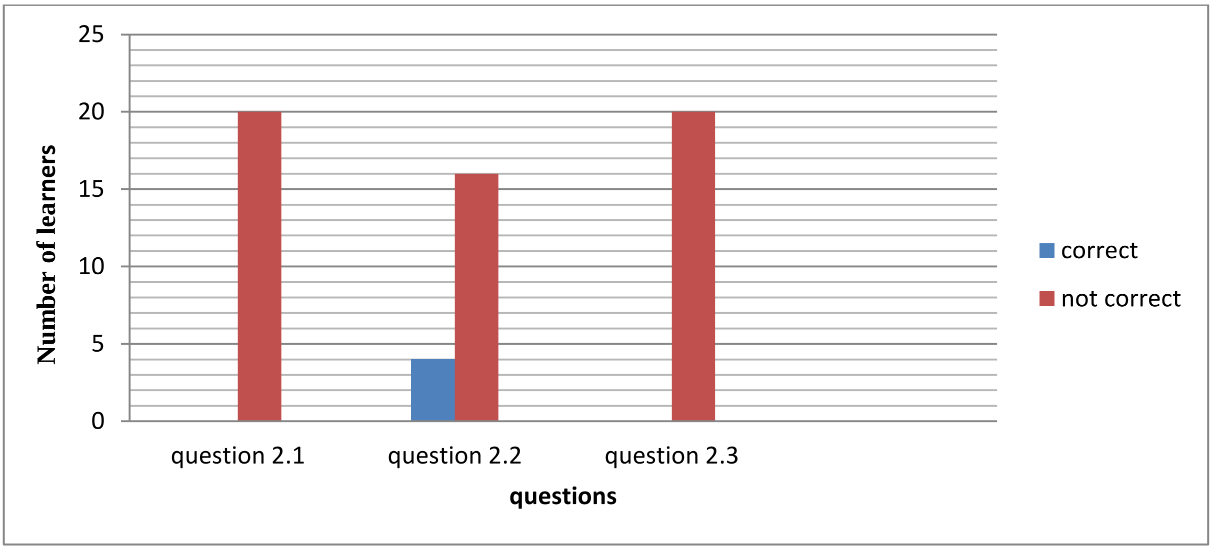

Figure 2: Performance of learners in questions related to concept of fractions and their operations

In question 2.1 of the question paper, all 20 learners failed to get the correct respond. In question 2.2 also about fractions, 16 learners got the question wrong and only 4 got it correct. In question 2.3, all 20 learners failed to get the correct response. The analysis paved the way to find ways to assist the learners. A selection of ten learners from upper primary and ten from lower primary was done by the researchers. The twenty selected learners by researchers were taught how to use the area model to deal with problems related to fractions and their mathematical operations. This was done for a week.

The worksheets which the learners used to work operations of fractions on were analysed. These worksheets were based on operations of fractions using area model. The product of their work was reorganized and the data which they yielded is presented below.

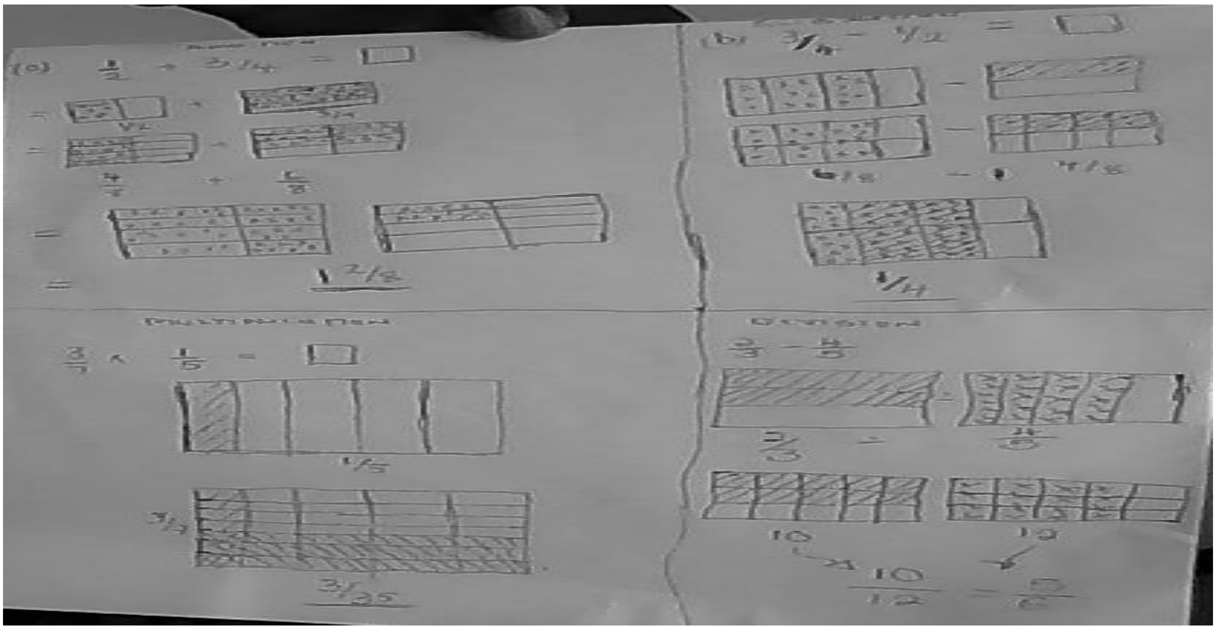

Figure 3: Synthesized work from learners who used area model to solve problems in operations of fractions

An analysis of the work done on the worksheets showed that learners were better placed in working out mathematical operations of fractions after an encounter with their teachers. They were cognitively involved and this means learner-centred approach was used even though physical resources were not available. In contrast, before the workshop, the majority of the learners were grappling but what is shown in Figure 3 is what all learners did to arrive at the required answer. This comes as evidence that use of IMTLS equips learners with the right skills to perform mathematical operation of addition of fractions. So, one of the problems was lack of resources which hampers the use of learner-centred. Schweisfurth (2011) found that learners become active in the activities in which they used the idea of area model to perform mathematical operation of addition of fractions. Learner-centred approach is not only achievable through use of physical resources but also through cognitively engaging learners in cognitive activities as they used inventive strategy and this promoted self-regulation as it related area and addition and use of models to represent a fraction (Weinstein & Mayer, 1986). Learner-centred strategy was involved only at lower primary when observed teachers brought for example an orange. A half was then presented as representing an orange which has been cut into two equal parts. The upper primary teachers could have involved learner-centred approach successfully if they had used area model after their introduction of fraction concepts and use the area model to teach mathematical operations of addition.

It was found that teachers' non-use of area model, an invented method prevented learners from understanding the concept of fractions and their operations. This explains why in the worksheets which were analysed most of the learners could not understand fractions and algorithms associated with operations of fractions. This is evidenced from the worksheets analysed after the learners were done with a classroom task on fractions. The majority failed to arrive at the required answer. However, the opposite is true when they were supported in using the area model. All the learners who were supported were able to follow an algorithm which gave them the right response after using the RMTL strategies which teachers could not use before. Absence of indication of work in which learners never involved inventive strategies in their workbooks observed during SBS was a clear indication that of failure of teachers to engage IMTL. This comes as a clear indication that their subject content knowledge on operations of fractions using models (Namibia Ministry of Education, 2015) in the curriculum is questionable. This is also evidenced in the data found and presented in the section of the statement of the problem in Figure 1.

Data from observation and analysis

Figure 3 came after observation of worksheets of students. These observations revealed that lower primary mathematics teachers used area model to present the concept of fractions to the learners as the worksheets revealed. From the document in Figure 3, it is observed that teachers even went to the extent of asking learners to draw shapes showing fractions like 1/2; 1/4; 1/3. Diagrams showing an apple split into 1/2; 1/4 and 1/3 were observed in the worksheets obtained from learners in contrast to what was observed during SBS when there was no sign of engaging learners in inventive strategies that the Namibia Ministry of Education (2015) syllabus encourages teacher to use. With the analysis of the results obtained from Figure 3, it shows that the lower primary mathematics teachers achieved teaching fractions through the use of area model, representing fractions being added using models and in doing so they engaging in a habit of mind of inventing. Cuoco, Goldeberg and Mark (1996) suggest that it is useful to make learners active. Before workshop done with teachers, teachers restricted learners understand fractions using a traditional strategy which does not allow them to participate actively in classroom practices. The teachers' failure to engage inventive strategy short changes learners since the introduction of concepts of fractions provides the cohesion and progression needed when teaching mathematics concepts at upper primary level and other levels support (Kriek & Basson, 2008).

The scenario in which teachers do not engage a habit of mind of inventing observed in lower primary is not similar to that observed when upper primary mathematics teachers teach operations of fractions. Upper primary mathematics teachers involved area model to teach operations of fractions only at the introduction level. The teachers indicated that parts of an apple obtained after dividing an apple into two equal parts represent two halves and most observed teachers brought a model and used the model to demonstrate in ideas about fractions. This did not go further when he started to show operations of fractions. Most teachers at upper primary restricted themselves to teaching practices where fractions were represented symbolically. Symbolically representing fractions makes learners not understand the roles fractions play namely; part-whole, measure, quotient (division), operator or ratio (Kieren, (1980). This short changes learners as cohesion and progression were lacking in teachers' teaching practices (Kriek & Basson, 2008). This does not support what learner-centred advocates (Sibuku, 1997; Weimer, 2002). Teaching without engaging inventive strategies is not supportive of cognitive constructivism and was not taking place among the learners before the workshop that teachers had. Learners' cognitive systems were passive as they continued copying what the teacher was presenting.

In lower primary, after the workshop, the teachers developed the habits of mind of the learners. Cuoco, Goldeberg, and Mark (1996) and Seeley (2014) advocate as evidenced from the fact that learners finally managed to add fractions when they fully involved with area model since learner-centred was embraced. Before the workshop with teachers, use of learner-centred learning was constrained as the learners' performances were not up to standard as evidenced in Figure 2. The fact that only two teachers in lower primary used area model while those two teaching upper primary distanced themselves from using area model is an indicator that the teachers had the fraction pedagogical content knowledge for teaching operations at upper primary. However, the two upper primary teachers have content knowledge but lack the pedagogical content knowledge to teach fraction promoting learner-centred. Observation done during SBS and after the workshop shows that lower primary teachers understood the need to teach fraction using area model while the upper primary teachers did not find the use of area model as useful. This allows answering research question as lower primary school teachers finally embraced the use of inventive strategies after the workshop while upper primary mathematics teachers used TMTLS to understand fractions and this answers research question 1.

Data from interviews and its analysis

Interviews were carried out with ten lower primary and ten upper primary school learners. The lower primary school learners were first interviewed and the last to be interviewed were those from upper primary. In response to interview questions which aimed to gain insight on strategies teachers use, the revelations from lower primary learners were that learners were in a position to define or explain what a fraction is. The theme which was a major in their definition was a fraction represents part of a whole. The other themes of what a fraction represents; measures, quotient (division), operator or ratio were not mentioned.

When asked whether they encountered challenges with learning fractions, learner 1 responded that, "*it is not difficult since I can draw, divide, shade the required portion, count how much is shaded, which represent the numerator, the total obtained represent the denominator"*. This reflects that classroom talk (Lemke, 1990; Krajcik & Sutherland, 2010) propose to be useful in learner-centred succeeded as learners managed to talk the mathematics language. Other procedures used to ensure teaching and learning of fractions and their operations engaging learner-centred teaching was revealed when learner 2 said, "*the teacher draws shapes on the chalk board, divide the shape into portions and explain. Sometimes, materials from the Namibian ministry of education are used by the teacher but they are not sufficient for us to interact with them"*. This statement from learner 2 supports the tenets of learner-centred approach (Weimer, 2002). When asked what the teacher does when learners do not understand fractions, some of the learners had this to say, "*the teacher repeats"*. There was no further probing to find out how the teacher repeats.

Interview results from upper primary learners who responded to research question 1 and 2 can be known through an excerpt which came from some learners.

Excerpt from the learners
The mathematics teacher must find alternative strategies for us. We do not understand operations of fractions. The ideas presented in the algorithm he presents are very abstract. It would be better if the idea of operations of fractions is related to real life examples. Maybe he does not have another strategy to use. However, we think there must be another method which can simplify this topic on mathematical operations of fractions. If throughout these weeks we are learning fractions the teacher does not come up with alternative methods for us to understand then his knowledge of operations of fractions is limited.

From the excerpt from the upper primary learners' responses, it is clear that they were struggling to understand fractions. Also, they revealed that the teachers' content knowledge and pedagogical content knowledge about fractions and their operations is questionable. These learners believed that the teacher must use other strategies that made their life easy as they will not keep on struggling to understand fraction concepts which are abstract.

Results

Mathematics teachers when teaching fractions used a combination of symbols and area model. However, this is done mostly by lower primary school mathematics teachers. The upper primary mathematics teachers distance themselves from the use of area model since in their classroom practices related to fractions they were never observed relating to any of those roles fractions play namely; measure, quotient (division), operator or ratio. These teachers concentrate more on use of symbols representing fractions. Teaching strategies used in teaching operations of fraction is a combination of symbols representing fractions and area model at lower primary level. At upper primary level, the mathematics teachers avoid the use of area model (Lamon, 2012). Some of the mathematics teachers had the content knowledge but some did not have and this is evidenced from Table 1. However, some upper primary teachers have the content knowledge but the majority lacked the pedagogical content knowledge. This is evident from what was observed that area model was used at the introduction and was never used throughout the lesson by upper primary level school teachers.

To respond to question one the data from the three instruments revealed that mathematics teachers at lower primary school level used a combination of RMTL and TMTL strategies. However, this is not the same with mathematics teachers teaching upper primary school level. They restricted their strategies to TMTL strategies. This is evidenced from data from the excerpt and also data obtained when the worksheets of the learners were analysed (see Figure 2). The learners were found to be capable of understanding concepts of fractions and their operations if strategies which comply with LC were involved. This is evident in Figure 3. All the questions on operations given to learners were done successfully by those learners who were involved in the intervention but could not be done before the intervention.

The intervention used was found to mitigate issues related to lack of materials to teach fractions and their operations. The strategy used enabled learners to actively participate cognitively. This paved a way to see how LC could be applied in the teaching of operations of fractions when teaching and learning materials were in short supply.

Conclusion

Some teachers have the content knowledge but they lack the pedagogical content knowledge. This then makes it difficult for learners to understand operations of fractions. At upper primary school level where they are expected to keep on using the area model the teachers did not use it. From what the lower primary school learners indicated during the interviews, use of area model mitigates some problems associated with operations of fractions.

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