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Enhancing visual literacy in the mathematics classroom: the case of Dar es Salaam

Visual literacy is defined as competencies that enable an individual to understand, interpret, use, generate, and evaluate visual images or messages. The role of visual literacy in teaching mathematics is to enhance learners' understanding of complex concepts, accommodate their needs, promote their logical and critical thinking, and develop their communication skills. To develop learners' visual literacy, teachers need to use meaningful teaching styles and strategies in mentoring and guiding their learners, giving them sufficient opportunities to engage in meaningful tasks. This study therefore aimed to answer the research questions regarding what mathematics teachers' understanding of the role of visual literacy in mathematics teaching is; and how their instruction in terms of teaching styles and strategies facilitated the development of visual literacy. A two-part conceptual framework was used: the first part focuses on teachers' styles and strategies and the second part on the integration of different visual media with text during instruction. This article reports on an explorative case study conducted with three Form 2 (second year of secondary school) mathematics teachers who were required to facilitate visual literacy in their classrooms. The data were collected through classroom observations and semi-structured interviews and a deductive analysis approach was implemented. The study revealed that a teacher-centred teaching style and direct instruction as teaching strategy dominated all three teachers' instruction. Information was provided to the learners in the form of demonstrations through the use of still media, and oral explanations, with inadequate opportunities for learners to engage in encoding and decoding visual information. We make the recommendation that teacher training programmes should focus on how teachers can use various teaching strategies in a learner- and teacher-centred style, but also how visual media can be made and effectively used by both the teacher and learners to develop their visual literacy.

Keywords: *Mathematics teachers; multimedia instruction; teaching; visual literacy; visual media*

1. Introduction

Teacher quality is directly related to learner performance (Venkat & Spaull, 2015). One of the factors affecting teacher quality is the opportunity to use new technology and the resultant new methodology (Crossfield & Bourne, 2017). The world in which learners live has changed and continues to change, particularly in terms of communication: "… the reason for that lies in a vast web of intertwined social, economic, and cultural changes" (Kress, 2010:5). So learners live in a world where technology is paramount in the provision of information, even in Africa, where

accessing technology is not easy in many areas. In parts of Tanzania, for example, use of the internet, cellular phones, tablets, and television is common and even prominent. It is therefore incumbent upon education systems to make use of the opportunities offered by this plethora of technological advances and visual inputs to improve teacher quality. It is however important to recognise that along with the use of technology and other media, classroom practices must be adapted in terms of teacher instruction.

In the mathematics classroom, teaching for conceptual understanding rather than for accommodation of knowledge has become a requirement of many education systems because, as O'Dwyer, Wang and Shields (2015:3) point out, "Teaching practices that help students to develop conceptual knowledge have been linked to achievement in the literature". Wangeleja (2010), writing about the introduction of the competence based curriculum introduced in Tanzania, stated that the Ministry of Education and Vocational Training (MoEVT) encouraged teaching for conceptual understanding, and that such teaching requires learners to be active participants in their own learning. To this end, the MoEVT made it mandatory for teachers to use visual media like still media (such as graphs), dynamic media (such as virtual and physical manipulatives), and technology to teach mathematics. The reasoning behind this decision was specifically related to enhancing the class participation of learners in mathematics lessons through the use of media they found interesting and enjoyable. The fact that learners are members of a visual stimulus driven society does not mean that they have acquired visual literacy skills (Felten, 2010) or are able to communicate visually (Hattwig, Bussert, Medaille & Burgess, 2012).

This study therefore aimed to answer the research questions of what Tanzanian mathematics teachers' understanding of the role of visual literacy in mathematics teaching is; and how their instruction in terms of teaching styles and strategies facilitated the development of visual literacy. For the purpose of this study, visual literacy is defined as competencies that enable an individual to understand, interpret, use, generate, and evaluate visual images or messages (Hattwig *et al*., 2012; Tillmann, 2012).

2. Teachers' instruction

Teaching mathematics is a challenge for many teachers. According to Steedly, Dragoo, Arafeh and Luke (2008:8), "Mathematics instruction is a complex process that attempts to make abstract concepts tangible, difficult ideas understandable and multifaceted problems solvable." This complexity can be reduced by representing mathematical ideas in multiple ways (Barmby, Bolden, Raine & Thompson, 2012; Murphy, 2011). When visual media play a central role in the learning environment, learner interest and involvement is encouraged (Ramirez, 2012; Reddy, 2007). Visual imaging contributes to the understanding of complex ideas, accommodates learners' needs, promotes critical and logical thinking, and enhances communication (Aisami, 2015; Bamford, 2003; Felton, 2010; Murphy, 2011).

Herein lies the problem: learners will benefit through active involvement in interpreting the visual media used to stimulate their interest and understanding, but only if they are visually literate (Murphy, 2011; Tillmann, 2012). For learners to be actively involved throughout the learning process, a teacher needs to adopt a learner-centred teaching style instead of learners merely listening to teachers' direct instruction in the form of oral explanations (Cai, Perry & Wong, 2009). This allows learners to be actively involved in creating their own conceptual

understanding through practical work, discussions, and discovery while the teacher guides and mentors the learning process (Wangeleja, 2010).

The role of a teacher is therefore to mentor and guide the learners by using appropriate and meaningful teaching strategies, which includes multimedia instruction. According to Reddy (2007), multimedia instruction in the mathematics classroom requires a teaching environment that is learner-centred, where not only the teacher, but the learners are involved with the media being used. Such a strategy grants learners the opportunity to engage with the content, to communicate their thinking, and to take initiative in their learning of mathematics. Mayer and Moreno (2010) explain that this learner engagement and enhanced learning happen because of the interconnection between the verbal and visual information channels in the brain. Raiyn (2016:115) describes this interconnection in terms of the storage of information in the hippocampus in place cells, from which the brain produces "cognitive maps" upon which the individual then acts. Visual information allows the brain to find "the shortest path between the source and the target destination". When mathematics instruction consists not only of text, but also allows learners to use different visual media, learners' understanding of the subject matter is deepened (Murphy, 2011; Naidoo, 2012) and, bearing Raiyn's (2016) explanation in mind, reaction time is shortened.

3. Visual media and their integration with instruction

Raiyn (2016) makes it very clear that analytical thinking skills can be increased by using visual media as a teaching strategy. He says that "such a strategy has three fundamental components: a teacher, as student, and a learning process" (Raiyn, 2016:115). The inference is that each of these components is actively engaged in the classroom. Visual media may be seen as "any external representation with a visual component" (Presmeg, 2014:636), while visual learning is the "assimilation of information from visual formats" (Raiyn, 2016:115). It is this assimilation process that is the foundation of visual literacy, which by implication goes beyond visual recognition, as it involves meaning-making (Felten, 2010). The concern in this regard is stated very succinctly by Shabiralyani, Hasan, Hamad and Iqbal (2015:223): "However, it is also imperative to redirect teachers' opinions, perceptions, experiences, failures and success while using visual aids resources". A redirection of the teachers' thinking within their classroom practice may be necessary in order for visual media to be as effective as they are purported to be in mathematics education. In Tanzania, the teachers do not have a choice in this regard: the national curriculum requires them to use still and dynamic media in the teaching of congruency, similarity, geometrical transformations, logarithms, and statistics, amongst other topics. This study was designed to discover whether the teachers in the sample were in fact actively working towards enhancing the visual literacy of their learners.

The old adage, a picture is worth a thousand words, rings true in the teaching of mathematics. Quadratics, for example, are made more accessible by using graphs to capture the concept. At the same time, quadratic graphs without verbal explanations would not make sense. Thus a combination of different modalities involving verbal explanations, visual representations and numbers is ideal (Murphy, 2011; Suh & Moyer, 2007). When mathematical ideas are represented in multiple ways, learners can participate and have the opportunity to develop a fully rounded understanding (Murphy, 2011). Importantly, learners do not possess visual literacy instinctively or as a result of their familiarity with the world of visual media – in the mathematics classroom, this skill needs to be developed through guided practice and training (Felten, 2010; Hattwig *et al*., 2012). Some scholars (Bamford, 2003; Cheunga &

Jhaveri, 2014; Roux, 2009; Tillmann, 2012) suggest that an appropriate starting point or skill acquisition in this regard would be the receptive end of visual images, i.e. where the main task is decoding a given image. Learners are then guided to understand, decode, and evaluate visual messages from various perspectives.

4. Conceptual framework

A two-part conceptual framework was used in this study. The first part is about teachers' teaching styles: teacher-centred, learner-centred, or a combination of both. Teaching for visual literacy requires a learner-centred style or the combination of a teacher- and learner-centred style. Strategies implemented in the classroom also need to be included here because learners should be actively involved during class time through meaningful learning activities like decoding (using, interpreting and evaluating) and encoding (generating and explaining) visual information (Bamford; 2003; Cheunga & Jhaverib, 2014; Murphy, 2011; Tillmann, 2012; Vasquez, 2010). Such strategies may include problem-based learning, discovery learning, cooperative learning and multimedia instruction.

So, the second part deals with visual media being integrated with text (printed/narrated) during instruction. Visual media can be categorised into still media and dynamic media. Still media are visual representations that do not involve movement, like pictures, graphs, charts, tables, drawings, maps, and even gestures (Holzinger, Kickmeier-Rust & Albert, 2008). Dynamic media speak of movement or even interaction, like physical and virtual manipulatives, simulations, applications and software packages such as GeoGebra, while non-interactive media includes animations and videos (Holzinger *et al*., 2008). Technology, such as calculators, computers, and other smart devices are used to facilitate the use of the dynamic media and also constitute multimedia instruction (Glenn & D'Agostino, 2008).

5. Methodology

In this qualitative case study, purposive sampling was used to select three Form 2 (second year of secondary school) mathematics teachers from three government secondary schools in the Ilala District in Dar es Salaam. The inclusion criteria were that they should have a minimum of five years' mathematics teaching experience and hold a Bachelor's Degree of Education or any other appropriate Bachelor's Degree. When this study was conducted, Teacher A was 55 years old, held a Bachelor of Business Administration with Education degree, and had 31 years of mathematics teaching experience. Teacher B was 32 years old, held a Bachelor of Science degree and had eight years of mathematics teaching experience. Teacher C was 34 years old, held a Bachelor of Education degree and had six years of mathematics teaching experience.

Each teacher was observed three times and interviewed individually immediately after the last observation. All observations were videotaped, and the interviews were audiotaped and subsequently transcribed. The observations provided information on specific aspects associated with the teaching styles and strategies used during instruction, as well as the classroom activities that provided the learners with the opportunity to encode and decode visual messages.

Through the interviews, insight was gained into the teachers' level of understanding of visual literacy; its role in teaching mathematics in general, as well as their motives for using particular media in the observed lessons. Credibility was strengthened through the richness

of the data, and dependability was enhanced by collecting data from different schools with different teachers using various methods of collection. The interview transcripts were given back to the teachers to verify their accuracy, thus allowing them to make changes and corrections where there were inaccuracies. Ethical approval to conduct the study was obtained from the Ethics Committee at the Faculty of Education of the University of Pretoria, and permission to conduct the study was sought from the Tanzanian MoEVT, and the District Education officer. Informed consent and assent letters were also provided to and signed by the teachers and learners respectively.

A deductive analysis was conducted using the themes as predetermined in the conceptual framework, namely the teachers' teaching styles and strategies, and integration of visual media with text. These themes were also the basis for the coding that was implemented.

6. Results

Since this study was qualitative, the findings cannot be generalised to the larger population, however the results are presented in sufficient detail so that the reader can arrive at an in-depth understanding of the cases being investigated. The results are presented according to the themes that are found in the conceptual framework.

7. Teachers' teaching styles and strategies

Although the teachers acknowledged that they were supposed to teach in a learner-centred style, they all applied a teacher-centred style. Their reasons were based on the length of the syllabus that needed to be completed, large class sizes with resulting discipline problems, and a lack of teaching and learning resources. They furthermore acknowledged their lack of competence in using a learner-centred style, especially given the conditions mentioned above. Teacher C claimed that not even during his teachers' training did he learn how to use a learner-centred style. Teacher B stated he always involves his learners in classroom discussions, which is sufficient and meaningful learner participation. All three teachers implemented a traditional teaching strategy, claiming: "…it makes it easier for learners to understand" (Teacher A); and "… because of the environment … the system does not support us to use new technology … most of the time we write on the chalkboard" (Teacher B). Teacher B mentioned he sometimes uses small groups, which is not ideal as the class normally ends up making noise and not doing what is expected of them. When they were asked about which other teaching strategies they use, Teachers A and C said they were not familiar with other strategies, while Teacher B said he sometimes uses problem solving. A brief description of each teacher's instruction follows.

Teacher A was observed while teaching similarity and statistics. There were 40 learners in the class. All three observed lessons were dominated by explanations and demonstrations done by the teacher, who wrote notes on the board that learners had to copy; she also asked basic oral questions such as: "The two triangles are similar under which condition?"; "How many book shops were there?" (Based on a pictogram on a chart); and "Isn't it?" to which the learners replied "Yes".

Teacher B was busy with sets and trigonometry at the time of the observations, in particular, angles of elevation and depression. There were 41 learners in the class. All three observed lessons were characterised by chalk and talk teaching as he explained and demonstrated the work on the board without involving the learners more actively in the lessons. During

the lessons, he assessed learners' understanding by asking them: "Did you get the point?"; "Are we together?"; "Is it right?" and "Is that clear?" to which learners replied in chorus, "Yes".

Teacher C was observed while teaching statistics and trigonometry. There were 95 learners in the class. All three lessons were characterised by demonstrations involving learners through straightforward and factual questions such as, "What is the formula for simple interest?"; "How do we find the class mark of the class interval?" and later, "By formula, class mark is equal to upper limit plus lower limit divided by what?" At the end of his explanations, he allowed the learners to work in groups and occasionally asked learners to demonstrate their answers on the chalkboard. While group work was supposed to be done, most of the learners were just chatting to each other. The teacher attempted to involve learners actively in the lesson through group work and peer to peer explanation on the chalk board, but these strategies were not successful.

Learner opportunities to decode and encode visual information

The teachers described their struggles to engage the learners meaningfully in creating visual representations or making visual aids, because of the lack of time. Teacher A mentioned that although she sometimes gave the learners activities in class, she normally spends more time on this during the 'subject clubs', the extra mural classes. All three teachers wished to provide more opportunities for their learners to be actively involved in their own learning and they believed that once learners became visually literate, they would gain a deeper understanding of mathematical concepts.

Although all three teachers gave homework to the learners in which they were required to both decode and encode visual information, there was little evidence of the learners being actively involved with the visual media during class time. In her statistics lesson, Teacher A required the learners to interpret a pictogram on a chart depicting a variety of shops in a specific area. During the trigonometry lessons, Teacher B gave the learners the following problem: *Find the height of the tower if the angle of elevation of the top of the tower is 34° from a point 20m from the ground level*. This required the learners to use still media to solve the problem. He also asked them to find the value of tan 34° which they had to read from their mathematics tables (they did not have calculators). During the statistics lesson, Teacher C gave the learners a problem where they had to use the given data to draw a frequency distribution table. Apart from these activities, the learners were only passively involved, simply watching their teachers decode and encode visual information.

Apart from these examples, the teachers only involved the learners through basic and straightforward oral questioning, requesting them to pay attention and to copy the work from the board. The teachers' main reasons for not allowing learners to do activities during class time, were time constraints and a jam-packed syllabus that needed to be worked through. Teacher A said: "But during the subject clubs [extra-mural activities], normally I involve learners in the learning activities that require them to generate visual representations or make visual aids". Teacher B explained that he usually required learners to perform tasks, but: "[t]he authority needs us to accomplish the syllabus, which is too long within a specified time. Thus why, most of the time, I minimise the activities that consume time which can prevent me from finishing the syllabus".

In summary, all three teachers used a teacher-centred style and traditional teaching as strategy, where information is provided to the learners by the teacher in the form of demonstration and explanation (Azeem & Khalid, 2012), with inadequate use of multimedia and poorly implemented group work as teaching strategies. The teachers gave the following reasons for their use of traditional teaching: not enough time for creativity, the length of the syllabus (too full), a lack of resources, class sizes, no training and/or knowledge of using other teaching styles and strategies, the belief that learners learn best from direct instruction, disciplinary problems, and a school system that did not allow other forms of teaching.

8. Integration of visual media with text

The teachers indicated that visual literacy in mathematics teaching would ameliorate their instruction and overall classroom practice, while also facilitating learners' learning. When asked about their use of visual media during instruction, some of the responses during the interviews were: "If I have a concept to teach, I explain and then demonstrate" (Teacher A); and "By using real materials, the teacher can make the subject clear" (Teacher B). Regarding the advantages visual media hold for learners' learning, the general feeling was that it not only simplifies the understanding of difficult concepts, but also saves time as learners come to understand concepts more quickly than when only words are used.

In their efforts to comply with the requirements laid down by the MoEVT, all three teachers used some form of visual media in their lessons, albeit only still media such as graphs, tables, diagrams, pictograms and charts in all of their lessons. Only Teacher A also used physical manipulatives to demonstrate similar triangles. When asked about the possibility of using computers in their classrooms, the common answer was "unavailability": "I would like to use them, but the computers we have are used in teaching computer literacy" (Teacher A); "We have few computers for academic office use only … I would like to teach mathematics using new technology such as the projector or laptop … It is time now for Tanzanian teachers to teach mathematics using new technology" (Teacher B); and "We have only one computer and it is for the school secretary only" (Teacher C). Calculators were a different issue, though: the learners were not allowed to nor did the teachers want them to use calculators. Teacher C said: "Learners at O-level are not allowed to use them during the national examinations, therefore it is useless to use them". All three teachers believed that learners learn best without calculators; they preferred that the learners did the calculations themselves to better understand how to get to the answer. Teacher A explained as follows:

> *"We have no calculators at all. However, it is better for learners to learn themselves because when calculators are used, they cannot get the concepts. Actually, they cannot follow the steps of doing calculations such as division with calculators. Rather to use the calculators is better to teach them step by step in order to know how to reach at the answer instead of using a short cut way (calculators). Personally, I don't like the use of calculators".*

Only Teacher A had models such as geo-boards that she could use. Table 1 below provides a summary of the visual media used by each teacher per topic.

Teacher	Topic	Still media	Interactive dynamic media	Non-interactive dynamic media	Technology
A	Similarity	Drawings	Models of similar triangles	None	Only the chalkboard was used in all the lessons observed
	Statistics	Symbols, Chart: pictogram, Bar graphs, Frequency distribution table	None	None	
B	Sets	Venn diagrams	None	None	
	Angles of elevation & depression	Chart: drawing Drawings Mathematical tables	None	None	
C	Statistics	Frequency distribution tables Drawings Chart: pie graph	None	None	
	Trigonometry	Drawings	None	None	

Table 1: Visual media used by teachers

The teachers preferred to explain a new concept in words initially, then used visual media to demonstrate the concept and further explain it, finally writing a summary of the theory on the board. More examples were provided from the textbook using oral explanations with still media, followed by the teacher writing the solution on the board. All three teachers explained that they found the use of text (written and verbal) in combination with visual media useful in their explanations, as visual media contributed to quicker and better learner understanding.

9. Discussion

Visual literacy as a concept was interpreted in a simplistic way: to the teachers visual literacy meant using pictures or images together with verbal explanations to teach a mathematical concept. It seemed that these teachers did not perceive how learners could be actively involved in developing visual literacy through the use of all sorts of visual media. Many of the aspects mentioned in literature (Hattwig *et al.*, 2012; Tillmann, 2012; Felten, 2010) did not form part of the teachers' understanding of the concept 'visual literacy' and its role in teaching mathematics, nor did they feel that their use of still media alone was limiting. They did not seem to recognise the importance of providing sufficient opportunities for learners to be actively involved in interpreting visual information and using visual media. In their thinking, they did not have time to explore a variety of visual media in class time because of the perceived overloaded syllabus.

How technology, and actually any visual media, are to be used depends on the topic and the desired outcomes of the lesson. The appropriate use of technology may enhance learners' learning, but inappropriate use thereof may in fact hinder such learning (Bransford, 2000). The advantages make the effort of overcoming the difficulties worthwhile: the teachers are assisted in explaining such difficult concepts as reflections, space and shape, as well as in addressing misconceptions, particularly those that may arise from a disconnection between

the mathematics classroom and the reality of the world outside. In classrooms where visual media are successfully implemented, learners are encouraged to make thinking visible and to revise and reflect, particularly in problem-solving. According to Bransford (2000), such classroom practices enhance communication abilities and improve learners' attitudes towards mathematics. While the participants in this study were aware of some of these advantages and even appreciated the need for the use of visual media, there was a generally observed inertia with regard to changing teaching styles to accommodate its use effectively. These teachers seemed to be comfortable with, or even entrenched in their established way of interacting with learners during instruction.

10. Teachers' teaching styles and strategies

All the lessons observed were uniformly teacher-centred and all of the teachers used traditional teaching with a hint of multimedia instruction, with one teacher bringing in a modicum of group work. They preferred direct instruction as opposed to participatory teaching strategies because it is "easier to conduct" (Teacher A), faster, which is important because of "pressure from the curriculum" (Teacher B), and less complicated to manage when there are "too many learners in the class" (Teacher C). Zilimu (2014) also found that Tanzanian mathematics teachers used whole classroom discussion most of the time due to the large number of learners in the classrooms. This is contrary to what has been prescribed in the Tanzanian Mathematics Curriculum Document (TMCD), in which teachers are required to use participatory teaching strategies such as cooperative learning rather than those that do not encourage learners' participation (MoEVT, 2010; Wangeleja, 2010).

The problem may be that teachers do not know what these strategies are, nor how they should be used during instruction, as Teacher C said during the interview: "I have no idea of other strategies". The same applies to teachers not incorporating a learner-centred teaching style. Teacher C, for example, said he lacked the pedagogical knowledge and skills for using any such style because it had never been part of his teacher training programme.

Learner opportunities to decode and encode visual information

The teachers were aware of the need to create opportunities for learners to participate at least orally in the lessons. Teachers A, B, and C frequently involved learners in lesson discussions, but only through asking simple oral questions. Yet, an essential element in the use of visual media for mathematics instruction with a view to bringing about visual literacy, is learners' full and active participation in the learning process through various lesson activities. According to Reddy (2007), using visual media in decoding and encoding activities in the mathematics classroom, makes a teaching environment more learner-centred. The sort of learning activities that can enhance learners' in-depth understanding were not implemented at all by these teachers.

11. Integration of visual media with text

These teachers mainly used still media in their classrooms for two reasons: they spoke of a lack of media resources at their schools, and they believed that in using still media, they were in fact sufficiently compliant with the requirements of the TMCD. Nevertheless, the TMCD (MoEVT, 2010) prescribes the use of a variety of visual media for mathematics instruction.

This situation is not exclusive to Tanzania, but is a reality in urban and rural schools in many countries in Africa and in fact all over the world (Moila, 2006). This implies a need for teachers to work around the absence of resources and virtual manipulatives by recognising the value of physical manipulatives. Carbonneau, Marley and Selig (2013) found that the use of physical manipulatives, where connections are made between what is experienced and seen, and the abstract properties of the problem, enhanced learners' knowledge and retention of material, while developing understanding and higher-order thinking. Physical manipulatives such as geo-boards can easily be made by teachers and learners using the available resources or even waste material. Although teachers themselves were allowed to use calculators, they neither recognised nor appreciated their value in teaching and learning. This stance is not unprecedented: Salani (2013) also found that some mathematics teachers disagree on the efficacy of calculators, particularly when it comes to the enhancement of learners' understanding and development of mathematical competencies.

The implementation of new technology and the attitudes towards this implementation have been the focus of several studies, MacCallum, Jeffrey and Kinshuk (2014:141), famously explained the major concerns in this regard: "Specifically, it is the perceived value of the new technology (perceived usefulness) and perceived effort needed to learn to use the new technology (perceived ease of use) that have been established as playing a major role in the adoption of technology". While Teachers A, B and C certainly perceived the usefulness of new technology and were positive and willing to use dynamic media such as software packages and YouTube videos, as well as technology such as computers and projectors, they felt that they lacked training, knowledge and skills. The problem therefore lies in the area of perceived ease of use. They felt that they had insufficient time in class to make it viable to use media, the value of which was not clear to them. They were comfortable and au fait with using still media alongside of verbal explanations, but they were not able to bring in media with a view to assisting learners in developing critical thinking, communication skills and understanding new and sometimes abstract and complex mathematical concepts. They used media to illustrate what they were saying in order to bring about understanding:

> *"I usually use both verbal and visual information to teach a new concept. The problem is the language because not all learners can figure out what is written. To make them understand easily, I try to draw some figures instead of using words alone. When you teach by showing them the picture or an image or an object, they get the concept within a short time rather than by using words alone." (Teacher B)*

These teachers were not averse to combining text with visual media during direct instruction – in fact, they were proficient in the use of still media as a tool to clarify or embed concepts. However, it is a misconception to believe that giving the learners a problem from the textbook at the end of the lesson involving decoding and encoding still media such as graphs, tables and drawings (Teachers B & C), is sufficient to actually develop learners' visual literacy. One or two decoding and encoding exercises at the end of a lesson does not help learners to adequately develop visual literacy. The introduction of manipulatives would go a long way to assisting the development of visual literacy as well as to bring the real world into the classroom. Reddy (2007) indicates that children prefer to do practical activities and experiment with different things. Objects that can physically be handled and observed create a realistic teaching and learning environment and also involve learners efficiently in the learning process (Ramirez, 2012; Reddy, 2007), allowing them not only to grasp content, but to be able to recall it and implement it at school, and in their later lives as citizens in the world of work.

12.Conclusion

The teachers who participated in this study demonstrated both willingness and intransigence when it came to the implementation of visual media. They were willing to use dynamic media, but, in the absence of such media, were content in their use of still media instead. They were intransigent in their communal attitude toward the use of calculators, however. The learners were not allowed by the education department to use such devices, but the teachers could not see any value in using calculators anyway. They did however recognise the usefulness of visual literacy. Even in a society where access to technology may be thought to be limited, the demands of the 21st Century have made themselves heard and information needs to be presented visually (Aisami, 2015; Roux, 2009). Learners who are exposed to technology in the form of cell phones, computers and television, are comfortable with the use of such technology and they are generally fascinated by visual media (Reddy, 2007).

The teachers in this study did in fact not comply with the requirements for effectively teaching visual literacy in their classrooms. The ultimate goal in teaching visual literacy in the mathematics classroom is to enhance learners' procedural and conceptual understanding of complex and abstract mathematical ideas as they translate these ideas into more visible and accessible concepts (Murphy, 2011; Naidoo, 2012). In order to do this, more than direct instruction in a teacher-centred classroom is essential. While direct instruction may certainly be necessary, this should be accompanied by optimal learner involvement in a classroom which is intrinsically learner-centred. The lack of teaching for visual literacy is not entirely explained by the lack of resources and time. Equally responsible for this lack is the absence of knowledge regarding different teaching styles and strategies as well as skills in enabling learners to efficiently encode and decode visual media. This would explain why these teachers were not complying with the TMCD, while believing that they were at least partially compliant.

Having access to dynamic media and new technology does not guarantee that teaching in the mathematics classroom enhances visual literacy. Teachers need to be provided with the necessary skills to facilitate visual literacy acquisition. While it may not be possible to provide classrooms with the ideal media that would enhance visual literacy, it is possible to assist teachers to make use of the available media in a creative and innovative way, and this would increase their 'buy-in' into the use of visual media that actually are available.

Ideally, a teacher development programme involving workshops, seminars and conferences should be introduced. In such a programme, teachers' knowledge and skills could be developed in terms of:

- Teacher-centred and learner-centred teaching styles.
- How different teaching strategies can be used alongside of traditional teaching with special reference to multimedia instruction.
- How to make and use still and dynamic media.
- Effective use of technology such as computers and data projectors, but in particular, the value and use of calculators in supporting the teaching and learning of mathematics.
- How they can use the everyday resources around them, specifically in terms of physical manipulatives, to create interactive media that learners can use in the classroom.

The assumption that trained teachers will know which media to use and how to make appropriate use of such media to actively engage learners in the teaching and learning process instead of passive on-lookers, is unfounded. This study has shown that trained teachers do

not have extensive knowledge on the use of visual media in the classroom. Specific training in this regard, particularly in terms of the efficient implementation of learning and teaching support material, should be purposefully included in teacher training programmes.

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