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Comparative Studies of Mathematical Literacy/Education: A Literature Review

S. P. M. Pillai[1], G. Galloway[2] and E.O. Adu[3]

Faculty of Education, University of Fort Hare, South Africa
E-mail: [1]<201309392@ufh.ac.za>, [2]<ggalloway@ufh.ac.za>, [3]<eadu@ufh.ac.za>

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ABSTRACT The purpose of Mathematical Literacy is to ensure that all learners develop an understanding of Mathematics and how to relate it to the world in order to use mathematical information and to make valuable decisions affecting their life, work and society. Mathematical Literacy is not a clearly defined term and internationally there exists a range of different conceptions of Mathematical Literacy. This study examines the concept of mathematical Literacy/education from the national and international perspectives. Comparisons are also made between different conceptions of Mathematical Literacy/education in countries like South Africa, Kenya, China, Australia and United States of America, and the contexts in which mathematical literacy/education can be applied in these countries. Mathematical Literacy educators across the world need to be conversant and knowledgeable about the vast array of topics. They must be able to understand everyday situations, for example, accounts, building calculations, pyramid schemes and so forth, to make the learners aware of how these issues are dealt with in real life.

INTRODUCTION

One of the reasons behind the implementation of mathematical literacy as an alternative subject to Mathematics in South Africa was the low level of learners' mathematical knowledge and Mathematical Literacy skills as shown in the results of international studies (Department of Education (DoE) 2003a). At present the countries general education and training (GET) learners are not participating in any such studies. Another reason for implementing Mathematical Literacy was to address the concern that Mathematics is too abstract, catering primarily to prepare students to proceed to further mathematically or scientifically oriented studies (Graven and Venkat 2007: 340). The general belief now is that Mathematical Literacy offers an alternative to learners who do not need it for this purpose.

Mathematical Literacy means practical mathematics that is beneficial to learner's everyday mathematical requirements and usage. The understanding of mathematical concepts is referred to as an individual's ability to use it for funded judgement (Doyle 2007). Many students share the perception that mathematics is a tough discipline. In most cases, students develop this perception because of using the wrong approach in learning mathematics (Siebert and Draper 2012). The new Curriculum and Assessment Policy Statement (CAPS) curriculum (DoE 2010) of South Africa is an achievement in that, it addresses mathematical concepts that relate to a more practical understanding of mathematics concepts from a more "hands on" approach and many educators who were involved in this development of mathematics literacy can be proud of. Kramer (2005) who pioneered mathematics literacy as a relevant but an alternative to school subject mathematics. Kramer introduced mathematical literacy and has represented it as a more functional approach to the pedagogy of mathematics education. This leads to a discussion of national and international perspectives of Mathematics and Mathematical Literacy.

Objective of the Study

The objective of this paper is to compare the concept of Mathematics literacy/education from the national and international perspectives.

Literature Review

The Definition of Mathematical Literacy

Comparing national and international purposes and the definitions of Mathematics literacy, the national purpose and definition closely relate to that of the Program for International Student Assessment (PISA) (National Centre for Education Statistics 2008b; OECD 2003). The

purpose and aims of PISA is to ascertain and measure how students process and apply their mathematical knowledge and skill in the real day-to-day situations (McCrone et al. 2008: 35). An international definition of mathematics literacy according to PISA (OECD 2003) based on the understanding that engaging in mathematics impacts on a person's capacity to apply mathematical concepts in various daily contexts (OECD 2003: 24; Gerber 2011: 101).

The interface between the international and national views is the emphasis being placed on the importance that mathematics and mathematics education plays in the world and the value of applying mathematics in people's personal lives, at the workplace and as participating citizens of the society. Further shared objectives are guiding learners to become engaged in mathematics and to understand and appreciate how it is embedded in everyday life situations. A point of difference, however is that nationally Mathematical Literacy refers to both as a subject and competence, while internationally it refers to competence only (Christiansen 2007).

From the purpose, aims and definition of Mathematics literacy the DoE (2011a) lists five key elements involved in Mathematics literacy namely:

- The use of elementary mathematical content: The use of elementary mathematical content based on general ideas to develop mathematics concepts through daily contexts.
- Real-life contexts: These contexts should be applicable and relate to the learners' environment, daily lives and contextual situations.
- Solving familiar and unfamiliar problems: Learners should have the ability and skills to interpret both familiar and unfamiliar real-life contextual problems they encounter in the world. They should have the ability to apply mathematical literacy and non-mathematical techniques to make sense of the mathematical context.
- Decision-making and communication through the use of appropriate mathematical terminology will develop mathematics literacy in a collegial way.
- Solving mathematical problems would help students apply daily skills and draw from a range of experiences that enhance mathematics literacy as a "user-friendly" application for solving mathematical problems.

DISCUSSION

Mathematical Literacy: South Africa's Perspective

In South Africa the term "mathematics literacy" refers both to a school subject and to the competency of individuals in mathematics where internationally it is mainly the latter (Christiansen 2007: 91). The original National Curriculum Statement (NCS) for Grades 10-12 (DoE 2003a) is based on the Outcome Based Education (OBE), social transformation and integration, and applied competence. These principles encourage a leaner-centred and activity-based approach.

Teachers' have different views on what they think mathematics literacy entails. Some tend to think that mathematics literacy is a more practical form of mathematics, whilst others believe that mathematics literacy is a different, but still difficult subject to master (Mbekwa 2006). It is important that teachers who have to teach mathematics literacy will have to be trained in order to be prepared to cope with the requirements of the subject. In the case of implementing the subject in schools, it seems that the DoE did not place adequate emphasis on the training of mathematical literate teachers before actual implementation took place (Mbekwa 2006). Effective mathematics literacy teaching and learning depends on teachers who understand and can teach learners to understand mathematical concepts and how it adds meaning to the learner's lives as well as how mathematics literacy ought to be applied in a relevant and applicable way aligned to the "real" life situations (SAUVCA 2003). Educators have to be trained to facilitate Mathematical literacy learning, rather than just teaching (Romberg 2003).

Research in schools also indicates that there are different approaches used by teachers in teaching mathematics literacy (Graven and Venkat 2007). Some follow a more mathematical approach, while others follow a more literacy approach (Graven and Venkat 2007; Mavuagara-Shava 2005). There is also a difference between teachers who teach in a content-driven approach (Venkat et al. 2009). It seems that there are different resources available for educators to assist them in creating a scenario for teaching Mathematical Literacy, but that they still have to work with updated material drawn from the environment. Venkat et al. (2009), therefore con-

curred with the Vygotskian theory that mathematical literacy is both embedded in social and cultural thinking and environments. In other words, mathematical literacy steams from the teaching and learning context where it is presented from. This Vygotskian approach ensures that the activities are current and authentic (South Africa 2007a; Graven and Venkat 2007; Mavuagara-Shava 2005) and that the learners can identify with the Mathematical Literacy contexts.

Venkat et al. (2009) stated that learners have more time to conceptualise, understand and apply their Mathematical Literacy skills more effectively through applying a learner centeredness approach encouraging learners to work in pairs and small groups and applying alternate solutions and problem solving methods and procedures through learner collaboration and processing of mathematics in a more practical way. This leads to a discussion on the international perspectives on mathematics education which contributes to this study.

Mathematics Education in India

According to the National Board of Higher Mathematics (2012), it is stated that a modern nation such as India has laid emphasis on the significance, importance and value of mathematics and mathematics education in schools. In addition, in India the importance and the value of mathematics and mathematics education is considered an essential life skill and hence mathematics is taught from a young age right throughout the schooling system. The importance of demonstrating the mathematically conceptualised ability to infuse calculation, estimation and predictability is embedded in the mathematics curriculum for school going children as well as in adult education programmes (National Board of Higher Mathematics 2012) through an organised mathematics education system. This therefore depicts the intensity for a mathematically educated society ingrained in the learners throughout their school life and embedded in the entire school system.

Mathematics Education in Australia

According to Planty (2008) whereby the discussion centres around the achievement of the Austrian school system based on the international report called Trends in International Mathematics and Science Study (TIMSS) this report showed that Australia performed better than both England and the United States of America (USA) in 2006, a new review of advanced mathematical sciences was completed whereby the international report revealed a decline in Australia's mathematical and science studies showing that the Australian results were below England and the USA (Planty 2008).

The Australian Curriculum, Assessment and Reporting Authority (2007) agreed that only one national curriculum is to be implemented as from 2013, with the focus on delivering quality education (Planty 2008). According to various literatures on mathematics education in the school curriculum, various documents and guidelines have become available to parents with information on numeracy, providing some guiding principles on how to support their children in their numeracy development. This is a clear indication that not only the school system has intensified mathematics education but has also involved parents as the primary source to assist their children to develop mathematical competency skills, recognising numeracy as a key pillar of mathematical education and learning as an essential component (Queensland Study Authority (QSA) 2007b: 1) of their curriculum. In addition the literature and QSA (2007b) mention that teachers have an important role to play in helping learners to become confident appliers of mathematics in their everyday lives (WSA 2007b: 1). A Queensland Certificate in Education (QCE) is awarded at the end of Year 12, with 20 credits has met the requirement for literacy and numeracy. In the QCE learners have the options to achievement in one of their three mathematics subjects in school or passing a short course in numeracy developed by the QSA (2009b: 1). Numeracy has clearly become an important and integral part in the Queensland school curriculum. However, there is no indication or description of a connection between Mathematics and numeracy in this curriculum.

Mathematics Education in China

Zhang (2012) states that China's mathematics education is embedded in its unique cultural history whereby mathematics in ancient China was developed and quite advanced during the period of the various Dynasties that shaped the Chinese culture. Zhang (2012) continues to con-

textualise the "dynasties" and informs us that China's traditional arithmetic education relied on individual endeavours whereby the government played an insignificant role. However, Zhang (2012) states that after 1840, foreign missionaries taught western mathematics in Christian school in China. Zhang further mentions that by 1862 the Astronomy and Mathematics Institute was established in the nation's capital whereby mathematics education began in earnest (Zhang 2012).

As from 1898 to 1949, Zhang (2012) informs us that the introduction of elementary mathematics was adopted building on a more western approach and system to mathematics and mathematics education which was clearly moduled on the European and the American systems of education, with a focus on using textbooks as a teaching and learning resource. The teaching methods were the traditional ones though, in which the teacher teaches and the student listens without much interaction between them (Zhang 2012). Clearly, a teacher dominated approach to teaching and learning mathematics shaped the educational approach to teaching and learning. As Zhang presents a chronological view of mathematics education in China, Zhang states that from 1949 the mathematics curriculum was evolving and being shaped into a more scientific approach to the teaching of mathematics. As from 1963, China issued new guidelines, based on the former Soviet Union's educational system aimed to develop learner's abilities of basic computation, spatial imagination, logic and analysis allowing students to learn through intensive practice and mathematical applications (Zhang 2012). It is evident that during the 1960's and 1970's mathematics education and mathematics teaching and learning adopted and adapted methods of mathematics teaching from other countries and applied it to the context of the Chinese people. According to Zhang (2012), during this period normal education and teaching activities in schools were destroyed as applications to manufacturing and labouring became the focus and hence there was a significant decline in the quality of mathematics teaching in China.

Mathematics Education in the United States of America

According to Riegle-Crumb and Grodsky (2010), mathematics was not adequately taught to children for generations. These authors claim that due to the inadequacy of teaching mathematics it impacted on the poor levels of mathematics' competency in America. Cohen (2011) concurs and expounds on Riegle-Crumb and Grodsky's (2012) observations and Cohen claims that the problem in the USA has a new urgency, it is defined and conceptualised as features notably different from those of the past stemming from realities such as they maintain that there are gaps in achievement gains among different groups such as the African-American and Hispanic students in the country who consistently score lower and exhibit lower achievement levels than their White and Asian American counterparts, even when taking social class and social standing into account, the discriminatory nature of the American society is therefore a contributing factor with regards to the disparities in mathematics achievement in the USA (Riegle-Crumb and Grodsky 2010). In addition, Riegle-Crumb and Grodsky (2010) maintain that students' race and family income and the school population is changing dramatically and has therefore impacted on mathematics results. In addition, Zhao and Qiu (2009), state that the multilingual language or language diversity whereby English is not the student's mother-tongue but remains a language of teaching and learning in schools. This report claims that language differences lead to a variety of challenges for teachers and students as the language of learning and teaching is not necessary the learners or the teachers mother tongue, hence making the language of learning and teaching mathematics a 1st additional language for learners. According to the statistics presented by the Federal Interagency Forum on Child and Family Statistics (2010) noting that many children learn to speak English well in school "whereby only five percent both speak a language other than English in the home and have difficulty speaking English" according to them so many students come from homes where English is not the language used in the home creates a challenge for teachers in communicating with the parents, made all the more difficult because, while the children often speak English, the parents often do not. Furthermore, according to Cohen (2011) and Ball (2009), the relationship of school to home is crucial to children's success, so the challenge of communicating with the parents is rapidly becoming culturally and linguistically more complex. Hence they maintain that there are

needs for reconsidering the problem of mathematics education and for designing a system for improving multilingualism in mathematics classrooms as well as bridging the linguistic gap between home and school. However, the education system exerts pressure on schools to perform better showing improved results. Furthermore these authors claim that states across the country are setting higher expectations whereby the schools are mandated to teach more mathematics to more students (Cohen 2011; Ball 2009).

Mathematics Education in Kenya

At the time of independence in Kenya (1963), the government adopted the existing Western system of education, which was 8-4-2- system and changed to 7-4-2-3 system in 1966, according to Eshiwani (1993: 36). Furthermore, Eshiwani (1993) states that "despite the richness in the country's tradition, many changes were required for modernisation" of the society. Due to inadequate natural resources in the country, there was a specially need to develop the human resource. "Education therefore was seen as an essential resource and a passport to economic development in Kenya" (Eshiwani 1993: 36).

Eshiwani (1993) further informs us that the current education system referred to as the 8-4-4 system was introduced in Kenya in early 1985, with an important feature of curriculum as 'course of study' as opposed to the previous system where national textbook was interpreted to be the curriculum. However, the new system forced the increase of secondary school mathematics content that has been a heavy burden to both students and teachers and hence a public outcry about the poor performance of mathematics at secondary school level has resulted in Kenya. Mathematics teaching and learning in the Kenyan classroom, where the teacher talks and dominates the mathematical learning process is known as a teacher-centered approach exists in Kenya. In such situations the students do not interact or learn to solve mathematical problems for themselves and hence students do not know *how* to apply the mathematical skill and processes required to master mathematics at the school level. In sum, the students are required to regurgitate the content as presented by the teacher, with a little understanding of how the process of mathematics is or can be applied in and to the "real life" contexts (Eshiwani 1993: 36).

CONCLUSION

Mathematics literacy in South Africa enables learners to develop their confidence in thinking mathematically to develop the mathematical skill and process to interpret, analyse and solve real-life problems in different contexts. However, it is evident in this paper that mathematics education in India originates from continuous dynasty changes but yet the focus on mathematics education in this growing young population is beneficial to the country. In Australia, numeracy is clearly an important component in the Queensland school curriculum, but there is no indication or description of a connection between Mathematics and numeracy in the curriculum. In China the teaching of elementary mathematics with the emphasis on applications to manufacturing and labouring needs indicates that the Chinese approach to mathematics education focuses on the importance of mathematics to enhance the country's economic growth. Mathematics education and achievement in the USA seems to be based on the students' race and family income. In Kenya, mathematics education and teaching still take on the dominant role of the teacher whereby learners do not have adequate input in the mathematical learning process but are rather taught to regurgitate mathematics information as imparted by the teacher in order to meet the standard requirement for mathematics certifications.

RECOMMENDATIONS

Mathematical literacy educators across the world need to be conversant and knowledgeable about a vast array of topics. They should be able to understand everyday situations, for example reading accounts, building calculations and calculus skills, developing pyramid schemes and so forth, to make the learners aware of how mathematics and mathematics literacy are dealt with in a real life context. In a way the educators are teaching a life skill, that scaffolds their mathematical knowledge through applied knowledge and computational skills. An educator should have the ability to relate the mathematics curriculum to the learners' contexts and background as a frame of reference. Learners have to realize the importance of being mathematically literate and skilled and show how mathematics literacy could benefit them in real life situations.

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