Mathematical connections and contexts

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Introduction

The Theme of the ISTE 2012 Conference is "Towards effective teaching and meaningful learning in Mathematics, Science and Technology Education". I considered a number of possible areas of interest to address in this Plenary which would appropriate not just to the mathematics education community who are part of this conference but also science and technology educators. Initially I wanted to give a talk on ethnomathematics as this is an area that I have done some research in over a number of years and continues to take a keen interest in its development. However, I remembered that this is not an Ethnomathematics Conference and even if this was of interest to most mathematics educators attending the ISTE Conference, it may not necessarily be very appropriate to other participants at the conference.

The second area that I considered for the Plenary Address related to Indigenous Knowledge Systems (IKS). This is an area that I have spent about 9 years of my life working in. One of the highlights of the time I spent dedicated to IKS was the development and the finalisation of the IKS Policy in 2004. This option for the Plenary Address was even more appealing to me as it would, to a greater extent, cover most of the ISTE 2012 participants. For instance, the National Curriculum Statement Grades 10 – 12 (General) has infused indigenous knowledge systems into the Subject Statements. However, I resisted the temptation and decided not to give a talk related to IKS. In fact the directive by the Conference Organizers steered me away from this as I was asked to focus more on mathematics than other areas of the ISTE Conference.

In exploring the literature on various studies in mathematics I came across three very provocative statements related to the Theme of the Conference which largely determined what I am planning to talk about in this Plenary Address.

The first statement comes from the work of Glenda Anthony and Margaret Walshaw: 'Effective teachers support students in creating connections between different ways of solving problems, between mathematical representations and topics and between mathematics and everyday experiences' (Anthony & Walshaw, 2009)

The second statement comes from the work of Abigail Sawyer: 'Helping students learn to make connections between various forms of mathematical knowledge as well as between mathematics and real-life experiences, is increasingly recognised as integral to effective mathematics learning' (Sawyer, 2008: 429).

The third and final statement comes from the work of David Wetzel: 'When I took Algebra in school, a long time ago, it was boring and I asked the same questions students ask today. All we did was work problems in class after the teacher demonstrated how to solve the problem on the board. I passed, although I hated every minute of the algebra class. Fast forward a couple of decades – has anything changed? In most cases no! My children learned algebra the same way I did, except this time they are completely turned off to mathematics. When algebra is connected with real life situations, it gives students a personal connection. They can draw upon their prior knowledge and life experiences to help make these critical connections. Everything else is evolving and changing, so should algebra continue to be taught the same way?' (Wetzel, 2012)

I am sure most of us participating at ISTE 2012 can relate to the statement by David Wetzel. At the one end there are many who were scared away from mathematics by this approach who are possibly not here today because they chose not to study mathematics any further. Some of us went on to master some level of mathematics, even majored or studied it at postgraduate level. However, most of us pursued mathematics, not because of how it was presented to us but because of the career possibilities that we knew could result from pursuing the subject despite the difficulties experienced in studying it. Our perseverance in studying mathematics to the highest level possible for us individually (not necessarily the highest mathematics level) does not necessarily mean that it made more sense or easier to understand the connections at various levels. The fact that I went on to study Mathematics, Chemistry and Physics at undergraduate level and also studies Mathematics at postgraduate level does not in any way mean I understood the connections thereof.

You will notice a common thread running through the three statements above. Connections in mathematical content and levels and between mathematics and other subject areas. The statements also refer to the idea and importance of contexts in mathematics. This is what I would like to share with the ISTE 2012 participants.

Connections in the National Council of Teachers of Mathematics

The National Council of Teachers of Mathematics (NCTM) published the *Principles and Standards for School Mathematics* in 2000. The *Principles* covered are Equity, Curriculum, Teaching, Learning, Assessment and Technology. The Standards relate to Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability, Problem Solving, Reasoning and Proofing, Communication, Connections and Representation. All these *Standards* are identified as critical for all levels of school mathematics. The *Connections Standard* specifies that instructional for all the school levels should:

- Recognize and use connections among mathematical ideas: By emphasizing mathematical connections, teachers can help students to build a disposition to use connections in solving mathematical problems, rather than see mathematics as a set of disconnected, isolated concepts and skills
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole: As students progress through their school mathematics experience, their ability to see the same mathematical structure in seemingly different settings should increase; As students develop a view of mathematics as a connected and integrated whole, they will have less of a tendency to view mathematical skills and concepts separately.
- Recognize and apply mathematics in contexts outside of mathematics: School mathematics experiences at all levels should include opportunities to learn about mathematics by working on problems arising in contexts outside of mathematics; These connections can be to other subject areas and disciplines as well as to students daily lives.

The *Connections Standard* emphasizes the importance of connections among mathematical topics and those between mathematics and other disciplines

Connections in the National Curriculum Statement

In 2003 the Department of Education in South Africa published the National Curriculum Statement (NCS) Grades 10 – 12 (General) whose intention was to lay the foundation for the achievement of goals by stipulating Learning Outcomes and Assessment Standards, and by spelling out the key principles and values that underpin the curriculum. The NCS is based on the following Principles: Social transformation; Outcomes-based education; high knowledge and high skills; integration and applied competence; progression; articulation and portability; human rights, inclusivity, environmental justice; valuing indigenous knowledge systems; and credibility, quality and efficiency.

Connections are deeply embedded and implied in the following description of mathematics in the NCS: 'Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of Mathematics itself. It is a distinctly human activity practised by all cultures. Knowledge in the mathematical sciences is constructed through the establishment of descriptive, numerical and symbolic relationships. Mathematics is based on observing patterns; with rigorous logical thinking, this leads to theories of abstract relations. Mathematical problem solving enables us to understand the world and make use of that understanding in our daily lives. Mathematics is developed and contested over time through both language and symbols by social interaction and is thus open to change' (Department of Education, 2003:9)

The NCS (Department of Education, 2003:10) further indicates the connections to real-world contexts, mathematical description of the learners' world and use of mathematics in the physical, social and management sciences as follows; 'An important purpose of Mathematics in the Further Education and Training band is the establishment of proper connections between Mathematics as a discipline and the application of Mathematics in real-world contexts. Mathematical modelling provides learners with the means to analyse and describe their world mathematically, and so allows learners to deepen their understanding of Mathematics while adding to their mathematical tools for solving real-world problems. Mathematics can be used in a wide variety of physical, social, and management sciences. An appreciation of the manner in which Mathematics has developed over time establishes its origins in culture and the needs of society'.

In analysing the South African curriculum, Mwakapenda (2008) argues that it provides opportunities for educators and researchers to see mathematics in ways that present mathematics as a discipline that has connections: it has links with itself and other disciplines. He continues to identify connections that according to his analysis are privileged in the curriculum. For instance, the connection between mathematics as a discipline and the application of mathematics in real-world contexts. The application of mathematics in real-world contexts is fundamental to the purpose and meaning of a number of studies in mathematics and will be discussed further in this Plenary Address.

Connections in Mathematics and with other Subjects

The following statement is attributed to E H Moore when he delivered his presidential address to the American Mathematical Society in 1902: 'Engineers tell us that in the schools algebra is taught in one water-tight component, geometry in another, and physics in another, and that the student learns to appreciate (if ever) only very late the absolutely close connection between these different subjects, and then, if he credits the fraternity of teachers with knowing the closeness of this relation, he blames them most heartily for their unaccountably stupid way of teaching him'. After this profound and challenging statement, Moore went on to advocate reforms in school mathematics and science instruction that would prompt a more coherent organization of the two subjects including overlaps between them. A lot has happened in curriculum reform since this Presidential Address by Moore. For instance, Frykholm (2005: 127 – 141) reports on an innovative model of secondary preservice teacher education that was designed to provide rich and meaningful experiences for beginning teachers to begin seeing and seeking connections between science and mathematics.

The connections between mathematics and science subjects like Chemistry, Physics, Biology are easier to recognize and take into account because in most cases Mathematics is required as a prerequisite in further study of these subjects. This is however not the case with various subjects like the Languages. Pial Das (2006) argues that 'reading provides both context and motivation for the mathematics students and that the integration of mathematics and reading is very important as shown in the study of English language Learner students' performance.

Mathematical Contexts

'The plethora of data that confronts us on a daily basis requires that we know more than simply being able to calculate. It demands that we understand the context in which the mathematical ideas are embedded and what those ideas are telling us in relation to the context' (Hurst, 2007:25). This statement by Chris Hurst is appropriate to introduce the second component of the Plenary Address. Mathematics becomes more meaningful the teaching thereof becomes more effective when a variety of contexts are taken into account.

The NCS (Department of Education, 2003:62) refers to the importance of reflection upon and inclusion of a variety of examples from cultural and social practices to enable access and affirmation for learners of Mathematics. 'Another aspect of providing access and affirmation for learners of Mathematics is to look at examples of Mathematics in the variety of cultures and societal practices in our country. Mathematics is embedded in many cultural artefacts which we experience in our daily lives: the murals of the Ndebele, the rhythm in the drums of the Venda, the beadwork of the Zulu and the Vedic art, to name a few. Architecture, games and music are rich fields to explore through the lens of mathematics. Ethnomathematics provides a wealth of more recently developed materials, sensitive to the sacredness of culture, for use in the classroom. The flexibility allowed by the curriculum also promotes the incorporation of local practices as starting points for applications or investigations. Ethnomathematics also stresses that Mathematics originated in cultures other than Greek, and that it continued to be developed in sophistication by many societies other than European. Projects in the history of Mathematics can be used to explore this.

It is not my intention in this part of the Plenary Address to go into the Ethnomathematical debates that have taken place over the years about the *Innocence of Ethnomathematics, Cultural activities and practices as Mathematics; Ethnomathematics as a starting point for mathematics; and many other interesting debates that have dominated this space*. In this Address I am strictly reflecting on the reference by the NCS to Ethnomathematical activities as an empowering context for mathematical understanding.

In 2004 the Human Sciences Research Council (HSRC) Press published a book edited by C. Keitel, J. Adler and R. Vithal entitled *Mathematics Education in South Africa.* One of the Chapter in the book is written jointly by Paul Laridon, Mogege Mosimege and David Mogari on *Ethnomathematics Research in South Africa*. The Chapter elaborates on the place of ethnomathematics in the South African curriculum and goes on to give examples of artefacts and indigenous games that may be used in mathematics classrooms. Other examples of Ethnomathematics as a relevant context in mathematical understanding are by

Abdul Ismael (2002) in his doctoral study on *An Ethnomathematical Study of Tchadji – About a Mancala Type Boardgame Played in Mozambique and Possibilities for its use in Mathematics Education;* Marcos Cherinda (2002) in his doctoral study on *The Use of a Cultural Activity in the Teaching and learning of Mathematics: Exploring Twill Weaving a Weaving Board inMozambican Classroom*; Mogege Mosimege and Abdul Ismael in a presentation at the 10th International Congress on Mathematics Education in 2004 on *Ethnomathematical Studies on Indigenous Games:Examples from Southern Africa*. There are many other ethnomathematical studies not indicated here that provide a rich context for mathematical understanding.

Conclusion

Effective teaching and meaningful learning in Mathematics, Science and Technology Education can be enhanced through identification and establishment of connections between mathematics and other subject areas. It can also be improved through reference to appropriate contexts that can lead to an increase in mathematical understanding.

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