WHY IS IT HARD TO ENGAGE STUDENTS? INVESTIGATING EPISTEMOLOGICAL THEORIES UNDERLYING TEACHING AND LEARNING MATHEMATICS

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Abstract: There is a considerable emphasis today on bridging the gap between theory and practice. On the other hand there is a divergence of thinking through a traditional perspective that mathematics exists independently of its applications and should be taught in its pure form. The purpose of this paper is to examine the key epistemological theories underlying teaching and learning mathematics from above (i.e. traditional approaches) and mathematics from below (contemporary approaches) and how they relate to adult numeracy education. This begs the question: Why is it hard to engage students and why can't we connect with both the real-world and mathematical abstractions?

Keywords: *engaging students, adult learning, mathematics and numeracy.*

INTRODUCTION

Research indicates that mathematics, writing, talking and listening are all critically important skills required for work, home and in the community environments (Howard, U. In Tett, Hamilton & Hillier, 2006). Nevertheless, there are differences between informal mathematics in people's everyday practice and school mathematics in formal education. Wedge (2002) conducted a study investigating these differences and argued that these differences are one of the reasons why adults don't recognize the informal mathematics in their everyday life as mathematics. On the other hand, numeracy has been defined by Crowther as the mirror image of literacy i.e. literacy and numeracy were seen as personal attributes that were needed to support the life-long aspirations of an educated person and that included communication between the so-called two-cultures (in O'Donoghue, 2002,pp. 47-48).

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The purpose of this paper is to discuss the key epistemological theories underlying teaching and learning mathematics from above (i.e. traditional approaches) and mathematics from below (contemporary approaches) and how they relate to adult numeracy education. This begs the question: Why is it hard to engage students and why can't we connect with both the real-world and mathematical abstractions?

After providing a brief idea about research method, the paper presents the definition of numeracy and mathematics and their interrelationship to the two perspectives mentioned above. It further discusses affective factors and math anxiety then investigates the epistemological theories of mathematics from above and below i.e. positivism versus constructivism, ethnomathematics and situated cognition and what school of thought the researcher supports; identity and power in numeracy context and finally discussion and conclusion.

Research Method

The researcher conducted an integrative literature review (Torraco, 2005), which involved reviewing, critiquing and synthesizing relevant literature (i.e. epistemological theories underlying teaching and learning mathematics from above-tradition and from below-contemporary approaches) to come to a new understanding of the topic (i.e. the relationship between mathematics and numeracy in the light of the above-below tension) at hand.

What is Numeracy and Mathematics?

This section aims at setting the scene for this essay by presenting the definitions of the various concepts we are dealing with i.e. numeracy and mathematics. Those two terms are being illusive and a lot of literature has been written about what do they mean and what do they stand for and how they are interrelated to each other.

Gal (2002) posits that numerate behaviour is one's response to tasks that contain information on a range of mathematical issues and ideas, such as quantity and number, dimension and shape, pattern and relationships, data and chance, and change. On the other hand, Coben (2000) asserts that to be numerate is to be competent, confident and comfortable at the same time with one's judgement on using mathematics in particular situations, the type of mathematics used and the degree of accuracy and how the answers relate to the situation.

In Adult Literacy and Numeracy literature there has been a constant reference to both literacy and numeracy together. Gal (2000) described the numeracy evolution by presenting the following:

- Mirror image of literacy
- Literacy (no explicit concern for numeracy)
- Literacy (concern for 3R's and basic mathematical skills)

- Functional numeracy (detached from literacy)

- Literacy (numeracy is recognised as an aspect e.g. quantitative literacy)

- Numeracy (independent life skill detached from literacy/equally important).

Maguire and O'Donoghue (2002) proposed a continuum of development of the concept of numeracy by presenting the following 3 phases showing increased level of sophistication as the person moves from level one to level 2 to level 3:

1. Phase 1: Formative – basic arithmetic skills

2. Phase 2: Mathematical – mathematics in context of everyday life

3. Phase 3: Integrative – mathematics integrated with the cultural, social, personal and emotional aspects.

On the other hand, Cohen (1995) specifies the following mathematical pedagogical standards:

- Mathematic faculty will model the use of appropriate technology in the teaching of mathematics so that students can benefit from the opportunities it presents as a medium of instruction.

- Mathematics faculty will foster interactive learning through student writing, reading, speaking, and collaborative activities so that students can learn to work effectively in groups and communicate about mathematics both orally and in writing.

- Mathematics faculty will actively involve students in meaningful mathematics problems that build upon their experiences, focus on broad mathematical themes, and build connections within branches of mathematics as a connected whole relevant to their lives.

- Mathematics faculty will model the use of multiple approaches – numerical, graphical, symbolic, and verbal – to help students learn a variety of techniques for solving problems.

- Mathematics faculty will provide learning activities, including projects and apprenticeships, which promote independent thinking and require sustained effort and time so that students will have the confidence to access and use needed mathematics and other technical information independently, to form conjecture from an array of specific examples, and to draw conclusions from general principles.

Accordingly, numeracy is the basic capability of knowing how to deal and utilise numbers in our everyday life to succeed in our transactions with each other e.g. measuring ingredients for cooking a cake, time management to fit in several tasks in the 24 hours of the day, calculating money for purchases either for home essentials or groceries. On the other hand, mathematics is the formal, schooled, academic theories that have got its own specific language and

certain expected behaviour and way of doing things. The issue here is how the education system and educators could bridge the gap between theory and practice which require a paradigm shift exemplified in curriculum and teaching techniques provided to students to enhance their engagement in mathematics and its useful application in their everyday life.

Affective Factors/Math Anxiety

Ormord (1999) defines motivation as an internal state that arouses us to action, pushes us in particular directions, and keeps us engaged in certain activities (p.407). Motivations are either extrinsic (i.e. from outside forces) or intrinsic (i.e. individual internal forces). For adult learners extrinsic factors could be related to professional development and intrinsic factors could be the desire for greater job opportunities or better parenting skills. Based on classroom observations of students through my working career and personal experience I believe that as we get older/mature, our motivation for learning becomes more internal i.e. intrinsic. Hence, as adult learners we tend to affiliate more with the culture of mathematics from below and how it's relevant to our everyday life.

In 2000 Nancy Miller investigated motivation in developmental algebra students at a community college. She found that the single strongest motivating factor was understanding. Motivation did not have to precede understanding but understanding spurred students to learn more mathematics (in Stafford-Ramus, 2008). This point has been reiterated by the Australian Education Council (1990) in A National Statement on Mathematics for Australian Schools *"children come to school enthusiastic and eager to learn mathematics and leave school with quite negative attitudes"* (p. 31). This raises the assumption that on one hand it could be related to a curriculum that has not been concentrating on understanding or on the other hand it could be related to the pedagogic process. Either or this has resulted on math anxiety which follows students in their adulthood as adult learners while dealing with any form of mathematical activity. Hence, that could relate to the issue of students becoming disengaged in the classroom and is a cry for educators to abandon traditional approaches of teaching (i.e. math from above.) and adopt more contemporary approaches (i.e. math from below).

Epistemological Theories

Theories about the nature of adulthood and learning in adulthood can help us to understand why our students have chosen to pursue education at this point in their lives and the characteristics that distinguish them from younger learners. Through my journey of discovering those theories as an educator there has been a lot of progress nevertheless, a better understanding of the social and cultural positioning of the students in our adult mathematics classrooms is required. It could help us in engaging our students in the classroom and connecting both the real world with the mathematical abstractions.

This section will be exploring the

various epistemological theories of mathematics from above and below and analysing those critically showing what I believe would fit best for me as an educator. My understanding is that 'mathematics from above' relates to the traditional approaches of Plato where theory plays a big role along with idealism, structure, constrain, rationalism, form, essentialism and pre-existing realities referenced through language. While 'mathematics from below' relates to Aristotle and emergent realities constructed via discourse, creativity, constructivism both individual and social, multiple contradictory positions and skills profoundly related to context and content.

Mathematics from Above - Horizontal

Mathematics from above is related to the traditional epistemological positions in adult education of mathematics in which Plato explained traditionally that mathematics would maintain the economic and social structure. He meant by that it should be for aristocracy to train the elite to assume effective management of the productive sector (Lands & Carson, 2002). This is the mathematics that is taught in school using the rote-learning method of teaching. Positivism is one of the theories that represent this andragogy (i.e. the science of adult education).

Positivism

The movement of positivism started in the early nineteenth century in France and Germany. Positivism has its impact not on reforming ethics, religion, and politics or philosophy, but on scientific methods. Harre (1981) stated that:

> *"The positivist tradition in scientific methodology has been based upon the principle that the only reliable knowledge of any field of phenomena reduces to knowledge of particular instances of patterns of sensation"* (In Lincoln & Guba, 1985, pp. 22-23).

Lincoln and Guba (1985) further explain that for the positivist there is only one tangible reality that is fragmented into independent variables and processes. Accordingly, those variables can be studied independently of the others then converge into that reality. Learning according to this philosophy would be through reception of information, absorption of facts and reproduction. Hence, teachers are viewed as experts in the field whose job is to transmit those facts to the students and are mainly concerned with the product i.e. delivering the information to the students through the rote-learning method.

I believe that we all have the right to education regardless of sex, colour, denomination or social status. Moreover, teachers are not Gods who are supposed to know everything. Adult learners experience should also be considered in the processes of learning. Hence, teachers should be more of facilitators to help students construct their knowledge and built on their own experiences.

Mathematics from Below - Vertical

Mathematics from below would be more relevant to the contemporary

epistemological positions in adult numeracy education i.e. Using and understanding mathematics to make sense of the real world and acknowledging numeracy as a social activity. In other words, turning mathematics into common sense. Theories illustrating this andragogy would be best exemplified in constructivism, ethonomathematics, and situated cognition.

Constructivism

Constructivism is an epistemological theory about adult learning advocating that learners construct knowledge for themselves; accordingly, we have to focus on the learner's thinking about learning not the lesson taught; and that there is no knowledge independent of the meaning constructed by the learner or community of learners (Hein, 1991). Accordingly, cooperative group learning is more encouraged over lecturing as it requires from students to be more active and reflective on their work which could be a means of making strong constructions that results in increased conceptual knowledge and more connections.

Draper (2002) discusses the importance of literacy instructions to the mathematics instruction by quoting various research conducted by the likes of Gallimore and Thrap (1990), Carpenter and Lehrer (1999) and the Principles and Standards of the National Council of Teachers of Mathematics (2000) where the communication standard states on p. 60 that the instructional programs from pre-kindergarten to grade 12 should enable all students to:

- Organise and consolidate their mathematical thinking through communication;
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- Analyse and evaluate the mathematical thinking and strategies of others;
- Use the language of mathematics to express mathematical ideas precisely (p. 523).

Draper (2002) refers to Neilson (1998) who explains that mathematics educators should view texts as providing readers, writers, listeners, speakers, and thinkers with the ability to create meaning through language. He then links with Flood and Lapp (1990) who advises mathematics teachers to look at literacy theories to find ideas about how people think and learn and how to help students become strategic learners. Flood and Lapp (1990) provide strategies before, during and after reading as a means of assisting math teachers to develop a structure for their students to engage in discourse that enables them to make meaning from reading mathematical texts.

Draper proposes and explains how teachers can use the Directed Reading-Thinking Activity (DR-TA) developed by Stauffer (1969) and the K-W-L reading activity (i.e. What I ***know***, What I ***Want*** to know, and What I ***Learned***) developed by Ogle (1986). Those activities help to provide students with a model and practice for how to strategically read a mathematics text.

Draper (2002) stresses the importance of teaching reading activities in mathematics by saying *"teachers have an obligation to help their students negotiate and make meaning of the text in order to keep mathematics within the reach of all students"* (p. 528).

Ethnomathematics

The term ethnomathematics was coined by D'Ambrosio in 1985 to mean *"the study of mathematical ideas found in many culture or sub-cultural group"* (Adam, 2004, p. 50).

Adam stated that literature shows that ethnomathematics curriculum have the following five possibilities that could be implemented in school programs:

1. Culture aspects are infused in the student's learning environment. This could be labelled as mathematics in a meaningful context i.e. drawing on student's own experience, or in their cultural environment, which also reiterates the New Zealand Ministry of Education (1992) perception:

... It is particularly important that mathematical learning experiences of Maori students acknowledge the background experiences, which have led to the formation of ideas and skills, which those students already have (Ministry of Education, 1992, p. 12).

2. Ethnomathematics has particular cultural content that is distinct from the universal mathematics concepts taught at most schools.

3. Ethnomathematical curriculum that focus on the mathematical world of the child's culture.

4. This possibility emphasises the issue that culture in all classrooms should involve cultural values, beliefs and culturally specific learning theories.

5. Ethnomathematical curriculum is an integration of the mathematical concepts and practices originating in the learner's culture with those of conventional, formal academic mathematics.

D'Ambrosio (1999) further explains that ethnomathematics is a means of building up a civilisation that rejects inequity, arrogance and bigotry by looking at the history of science and mathematics through new lenses. *"It is the essence of ethics of diversity: respect for the other, solidarity with the other, cooperation with the other"* (p.35).

As ethnomathematics considers the cultural background of students and their learning environment, it is advocating the concept of learning from below by fusing the formal world of mathematics and how it could be utilised in everyday life by the students. Accordingly, it's advocating a harmonious learning environment that enhances creativity, reinforces cultural self-respect and offers a broad view of mankind.

Situated Cognition

This is a recent theory concerned with the nature of knowledge acquisition that promotes real and authentic learning (Matang, 2006). Wilson and Myers (1999) proposed

the following principles presented in Table 1 as key insights of situated cognition for the design of learning environments:

Various research conducted in this field harks at the issue of numeracy education in real life or at the workplace that requires a fundamentally different curriculum and pedagogy from that of school mathematics. Such curriculum as highlighted by FtiszSimons (2005) should encompass knowledge and skills to enable the generation of new knowledge to solve problems that cannot always be known in advance. This is reiterating the continual tension between the traditional and contemporary epistemological theories of mathematics from above and below and their impact on teaching and learning mathematics.

Identity and Power in Numeracy Contexts

Various studies show that numeracy transforms students' identities. Swain (2005) explains the term identity by referring to

Table 1: Situated Cognition Principles Relating to Learning Environments

Situated Cognition Principle	Relatedness to Learning Environment
Learning in context	Thinking and Learning make sense only within particular situations.
Communities of practice	Communities construct an define appropriate discourse practices.
Learning as active participation	Learning is seen in terms of belonging and participating in communities of practice.
Knowledge in action	Knowledge is located in persons and groups actions, which evolves as we participate in and negotiate our way through new situations.
Mediation of artifacts	Cognition depends on the use of a variety of artifacts and tolls, mainly language and culture.
Tools and artifacts as cultural repositories	Tools embody the history of a culture
Rules, norms, and beliefs	Cognitive tools include forms of reasoning and argumentation that are accepted as normative in society.
History	Situations make sense within an historical context e.g. past experiences and interactions of participants.
Levels of scale	Cognition can best be understood as a dynamic interplay between individual and social levels.
Identities and constructions of self	People have multiple identities, which can sever as tolls for thinking and acting.

SOURCE: Wilson, B.G. & Myers, K.M. (1999). *Situated cognition in theoretical and practical context.* pp. 14-15. Retrieved 15 April 2008 from http://carbon.cudenver.edu/~bwilson/SitCog.html.

Mendick (2005a:205) who interpreted it as: *'identity is multiple and therefore identities are socially constructed, negotiated and performed; they are unstable and shifting: they are frequently contradictory; and different identities can be adopted at different times in different social contexts"* (p.7).

Moreover, Swain (2005) explains the concept of 'habitus' which was developed by Bourdieu in 1979. As people's experiences become more consolidated and reinforced, the habitus become more durable and internalised and habitualises the way people think and behave. Swain (2005) further relates this concept to mathematics by saying that students unconsciously believe that they are not good at mathematics and internalise those feelings until they accept them as their way of being and accordingly express them in their interactions with others.

Taffe (1989) explains the relation between 'math anxiety and 'math blight' as a social dimension. He believes that everyone is affected by these blight even mathematicians themselves. He supports his point of view by giving illustrations from groups of the Australian National University students (first year to PhD) through an informal survey on attitudes towards mathematics. The spectrum of the survey was: math anxiety – unease – boredom- neutrality. Results shows that students suffering from blight (math anxiety) are mainly mature students who left study for years and are returning back. Their main fear is related to any teaching methods that are similar to their school days which were traumatic to them.

I believe that people change through the years and their priority and identity follows in the same footsteps as we meet new people and belong to different communities which impact on us and accordingly changes our habitus. This links real life to the school context and the power of learning of numeracy and mathematics which gives more confidence to the learner.

Relating to the previous discussion of the definition of numeracy, we could say that numeracy gives power to the person by helping them recognise their identity and worth within their community and wider society. This power is acquired through gaining knowledge or control of a certain situation they found themselves in i.e. it could be more of an empowerment.

Discussion and Conclusion

Mathematics educators who are advocates of reform are hoping to challenge the beliefs and routine of school mathematics tradition in order to help students gain meaningful, lasting and useful knowledge (Grant, 1998 & Noddings, 1993 In Draper, 2002). Those educators have called for teachers to move away from teaching by telling (i.e. traditional mathematics from above) to move towards the constructivist teaching paradigm (i.e. contemporary mathematics from below).

This article discussed the key epistemological theories underlying teaching and learning mathematics from above (i.e. traditional approaches) and mathematics from below (contemporary approaches) and how they relate to adult numeracy education. Looking at those

various theories may help unravel the answer for the question: Why is it hard to engage students and why can't we connect with both the real-world and mathematical abstractions?

This could do with traditional theories of school teaching of mathematics which renders lots of students leaving with math anxiety. I would be more of an advocate of using the contemporary approaches of adult numeracy education. Being taught under the traditional education system left me suffering from math phobia for years or as referred to in literature as 'math anxiety'. Investigating those epistemological theories helps shed light on reasons behind math anxiety, its negative impact on students and how to start looking at mathematics through a brighter lens.

As an educator I relate to the ehtnomathematics approach in which students culture should be one of the main considerations in shaping the curriculum. On the other hand, the situated cognition approach is also valued as school mathematics should be taught in a way that could be more useful to the students once they are in the workforce. This is echoed by a study mentioned by Macleod and Globy (2003) about the research conducted in 1985 in Brazil by Carraher et al on street market boys demonstrated that street mathematics is different from school mathematics. That attracts the attention to the issue of transferability of knowledge.

True that doesn't make it any easier for educators/teachers to balance between situated practice and overt instruction. Nevertheless, with persistence and regular training, educators can perfect the art of teaching and at the same time serve their students the best way they can by helping them getting engaged and transferring their mathematics learning to their everyday life.

BIOGRAPHY

Dr Siham El-Kafafi is a Senior Lecturer in Management at the Faculty of Business, Manukau Institute of Technology, Auckland, New Zealand. She is the regional editor for World Journal of Science, Technology and Sustainable Development (WRSTSD), the World Journal Entrepreneurship, Management and Sustainable Development (WJEMSD) (www.worldsustainable.org), the Intermodal Transportation Research Journal, Inderscience Publisher, and editor and reviewer for other international journals. She is also a Member of the Award Committee for the International Society of Management Science and Engineering Management (ISMSEM) Advancement Prize for Management Science and Engineering Management (MSEM). Besides Dr El-Kafafi's academic and research experience, she has got wide consultancy experience with national and international businesses in the areas of business excellence, quality management, team work and leadership. Dr El-Kafafi currently teaches in operations business management, quality management, leadership, organization and management, quality assurance, business ethics, project management, and industry training in the areas of quality management systems, leadership, teamwork and business excellence.

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