

A FRAMEWORK FOR THE ANALYSIS OF VALUES THROUGH A MATHEMATICAL LITERACY LENS

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This paper aims to offer a framework to interrogate how learners make sense of values in Mathematical Literacy lessons. Through an exploration of the curriculum materials, a framework that uses, the Bloom's taxonomy to analyse the cognitive levels of the tasks in the materials against mathematical competency and knowledge areas was developed. Findings from this study show that there is merit in the use of the framework to analyse values in Mathematical Literacy

INTRODUCTION

Pundits concur that education systems play a pivotal role in fostering and developing values in learners. In South Africa the values and rights enshrined in the Constitution and the Bill of Rights resonate in the Schools Act. Society is making greater demands on its citizens to be numerate and demands that learners become more engaged with school mathematics (Bishop, 2007). The introduction of mathematical literacy into South African classrooms further reinforces this engagement by students. The OECD/PISA (2003) defines mathematical literacy as:

... an individual's capacity to identify and understand the role that mathematics plays in world, to make well- founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (p. 10)

The National Curriculum Statement (Grades 10-12) for Mathematical Literacy (Department of Education, 2001), states the following about education and values:

Values and morality give meaning to our individual and social relationships. They are the common currencies that help make life more meaningful....An education system does not exist to simply serve as a market.....It's primary purpose must be to enrich the individual. (pp. 4-5)

Values may be imparted by example (Nieuwenhuis, 2007) or clarified through discussion, debate and negotiation (2004) suggest that values are implied in the mathematics curriculum, mathematics teaching and mathematics itself. This also applies to the mathematical literacy curriculum and classroom.

Mathematical literacy may be taught through contexts giving rise to difficulties such as issues of language and the Nieuwenhuis (2007). Values in mathematical literacy are inculcated through the nature of the content, context and an individual's experience in the mathematics classroom. These values provide the cognitive and affective lenses which modify and shape one's perception and interpretation of the world (Seah &

Bishop, 1999). Since explicitly alerting students to values in a mathematical literacy lesson or articulating them anywhere is not a norm in mathematical literacy, values education may appear to have a hidden agenda. This paper forms a part of a larger study which aims to understand how learners make sense of values in Mathematical Literacy lessons. This paper, therefore reports on the development of tools necessary to carry out this analysis.

In an attempt to understand the socio-moral and cognitive development of the learner in the classroom, I chose to refer to the work of Jean Piaget, Lawrence Kohlberg and Lev Vygotsky. Piaget (1932), whose focus was the moral development of children, was of the opinion that individuals use their interactions with the environment to construct and reconstruct their knowledge of the world and considered morality to be a developmental process. His theory, if applied to values education, suggests that the teacher whose task is to provide students with opportunities for personal discovery through problem solving rather than indoctrination through societal norms is instrumental in the moral development of a learner (1932). In attempting to define moral development in terms of cognitive growth, Piaget identified the following four moral judgment dimensions which demonstrate a distinct correlation to his concept of cognitive development: (i) absolutism of moral perspective, (ii) concept of rule as unchangeable, (iii) belief in immanent justice, and (iv) evaluation of responsibility in terms of consequences (Lickona, 1976). Criticism levelled at Piaget is that he paid very little attention to the impact of social interactions and differing cultures on development (Sigelman & Rider, 2009). He paved the way for the theory of moral development advanced by Lawrence Kohlberg.

Kohlberg (1984) developed a system for categorizing the moral reasoning in human beings into six stages. Central to this theory is the notion that the moral growth of human beings progresses through an invariant sequence – a fixed and universal order of stages, each of which represents a consistent way of thinking about moral issues that differs from the preceding or following stage (Sigelman & Rider, 2009;). The age of the individual, regardless of cross-cultural moral norms and beliefs, plays a vital role in this development. The six stages, as identified by Kohlberg, relate to moral thinking. He further suggested that associated with moral judgement is the concept of sociomoral perspective; a reference that is made to the point of view an individual takes in defining both social facts and sociomoral values (Kohlberg, 1976). There are three broad levels of social perspective that correspond to the three levels of moral judgement. His non-subscription to the view that values education comprises of a moral agenda that prescribes a list of values to be learnt (cited in Nucci, 2001), resonates with my view on values education. Simpson (1974) suggests that Kohlberg's stages are not culturally universal as they are based on western philosophical tradition. Her proposal for the transformation of his cognitive-developmental theory into a cognitive-affective-conative developmental theory is based on the claim that it will give equal regard to three facets of the human personality: thought, emotion and motivation (Simpson, 1974). Carol Gilligan (1982) points to a gender bias in

Kohlberg's theory Simpson (1974) suggests that Kohlberg's stages are not culturally universal while Gilligan (1982) points to a gender bias in the theory.

The socio-cultural theory of learning suggests that characteristic to human evolution is the development of higher order functions through social interactions. Lev Vygotsky (1978) was of the view that in order to understand the human development of an individual, a study of the individual and the external social world associated with him needs to be undertaken. Vygotskian theory (Vygotsky, 1978) suggests that each developmental stage is determined by genetic, maturational and socio-cultural factors. Socio-cultural theory (Vygotsky, 1978) differentiates between experiences produced by the individual's contact with the environmental stimuli and those shaped by interactions with symbolic mediators. Central to Vygotskian theory is the Zone of Proximal Development (ZPD). Vygotsky (1978) defined the ZPD as the:

... distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers. (p. 86)

Within the ZPD, through social and cultural interactions, learners receive instructional support from experienced peers and teachers in a particular mathematical literacy context.

The Values Education Study Report of the Australian Government (2003) states that cognitive-developmental theorists' argue in favour of values education being "promoted through the development of reasoning" while critics of this approach focus on the neglect of the behavioural and emotional components of character and the absence of any attempt to determine whether the stated values resulted in behavioural change" (p. 35). I do not claim that any one approach to be most effective. The adoption of an approach is context dependent. At times a combination of approaches could prove to be more effective than the adoption of any single theory. While the literature does offer suggestions about possible strengths and weaknesses of approaches, I did not find any strong claims in the literature to warrant my not using the cognitive-developmental approach.

FRAMEWORK FOR THE ANALYSIS OF VALUES

This section outlines how the framework for analysing the values in a mathematical literacy lesson was developed. The framework is divided into five domains, namely: content categories, expected mathematical literacy competencies, Bloom's taxonomy, evidence of values and the value itself. In order to appreciate how the learners understand, identify and implement the values inherent in the Mathematical Literacy lessons, I carried out an analysis of the classroom materials looking at the mathematical content in the learner materials. A content review of the textbooks, learner worksheets, assignments, tests and examination papers was conducted and classified into the following five content areas: compound growth and finance; measurement; numbers and calculations; patterns, relationships and representations;

and representation of statistical data. Table 1 provides details with respect to the content areas and the related sections.

Content	Related learning objectives
Compound growth & Finance	Banking loans; break-even analysis; budgets; cost & selling price; exchange rates; income & expenditure; inflation; interest; profit & loss and tariff systems.
Measurement	Calculation of area, perimeter & volume; conversions; measuring length, weight & volume; temperature and time.
Numbers & calculations	Fractions; number formats & conventions; operations using numbers; percentages; proportions; rates; ratios and rounding
Patterns, relationships & representations	Patterns & relationships; representation of relationships in tables, charts & equations.
Representation of statistical data	Non-violence

Table 1: Content categories in ML & related learning objectives.

The content in Mathematical Literacy may be situated in contexts requiring learners to apply their mathematical and critical thinking abilities. Table 2 below provides a more detailed description of each competency category. The six competency categories suggested by Jaftha, Mhakure and Rughubar-Reddy (2012) in their study on Quantitative Literacy and social justice was adapted and used to analyse the competencies required in the Mathematical Literacy classroom.

Bloom’s Taxonomy consisting of the knowledge dimension and cognitive process was also used in the analysis the cognitive levels of activities from the learner materials. For the purpose of analysis the six cognitive process dimensions, namely: remembering, understanding, applying, analysing, evaluating, and creating were used.

Finally I examined the mathematical content of the activities in the learner materials for evidence of values. Discussions with colleagues and observations of their lessons in the Sathya Sai schools in South Africa and abroad, together with my own study of values in education, have convinced me that values are also embedded in the mathematical content. Sathya Sai schools in my analysis of the Mathematical Literacy lessons. I do not claim that that the methods used by the Sathya Sai schools nor the set of values to be the best. I found the list of values very comprehensive and suitable for my analysis. The values embedded in the South African constitution are integrated in this list.

Competencies	Core descriptors of competencies
Comparing numbers	Conversions of numbers from one form to another
Critical thinking ability	Interrogates the content & contexts; checks the validity of the solutions.
Data representation	Familiar with data representation (tables & graphs); analysis & interpretation of data from varying formats
Reading data from texts, charts & tables	Making sense of numbers in charts, tables & texts; comparing data in graphs, tables and texts
Procedural competencies	Routine calculations; relationships between quantities; substitution and manipulation of formulae
Writing proficiency	Effective communication of information; explains understanding of concepts; applying knowledge to novel situations

Table 2: Expected Mathematical Literacy Competencies.

Content	Competencies	Bloom's Taxonomy	Evidence of Values	Value
Compound growth & Finance	Comparing numbers	Remembering	Explicit in either context or content	Love
Measurement	Critical thinking ability	Understanding	Implicit in either context or content	Truth
Numbers & calculations	Data representation	Applying	Explicit in both context or content	Right conduct
Patterns, relationships & representations	Reading data from texts, charts & tables	Analysing	Implicit in both context or content	Peace
Representation of statistical data	Procedural competencies	Evaluating	Value absent from context and content	Non-violence
	Writing proficiency	Creating		

Table 3: Summary of the framework.

The one hundred and eight sub-values are pooled into five major groups, namely; truth, right action, peace, love and non-violence. I also sought to establish whether the values are explicit or not in the contents and contexts of the Mathematical Literacy lesson. Table 3 provides a summary of the framework that resulted from the analysis of learner material. Table 3 was then used to analyse a mathematical literacy lesson.

ANALYSIS OF A LESSON USING THE FRAMEWORK

This paper reports on the exploration of the views of five grade 10 learners from a public secondary school. The school is situated in a low income, residential area in the Cape Flats region of Cape Town, South Africa. The learners were from the first cohort of students taking mathematical literacy at the senior secondary level. A discussion on what the study was about and an illustration of how to identify the values was presented. Classroom lessons were observed and videotaped to capture the learners' participation and attitude during the lessons. This paper focuses only on a lesson on simple and compound interest. The following were the questions under review:

1. "Zandile takes out a bank loan of R13 500 to pay for an urgent medical operation. The bank terms are 12% p.a. compounded over two years, compounded annually. How much money must Zandile repay the bank?"
2. "Bongani invests his first Christmas bonus of R750.00 in a bank that offers interest rates of 9% p.a. compounded yearly. How much interest will he have earned after 12 years?"
3. A bank charges 11% interest p.a. on loans over 4 years. Oluwethu borrows R12 000. Calculate: (a) the amount of interest due, (b) The total amount to be repaid, and (c) the monthly repayments needed.

A focus group meeting was held with these five learners after the completion of the classroom visits. This was a two part meeting. Firstly the learners had to comment on the values that they attributed to their general experiences in the mathematical literacy classroom. Thereafter they were shown the video footage of the lesson and asked to identify values in the lesson. A list of values to assist with the identification of values was given to the learners. The learners had to support their claims with evidence of where or how these values manifested themselves in the lessons.

The findings based on the viewing of the video are divided into three sections as follow: general values associated with the classroom experience, values in the context and values in the mathematical content. Table 4 gives a summary of the values identified by learners together with the evidence. During the focus meeting, consideration was first given to the values learners attributed to their experiences in the mathematical literacy classroom. Learners were of the opinion that the subject mathematical literacy was looked down upon by both the educators at their school and the learners who did mathematics. One learner commented that: "... the other learners think that they are better because they do maths ... They think that we are stupid ... they make us feel stupid ..."

Value	Evidence of value in the lesson
General values associated with the classroom experience	
Values about classmates:	
Consideration	Learner that was finding difficulty understanding a concept and required repeated explanation.
Focus	Learners concentrating on lessons
Spirit of inquiry	Learners asking questions to learn more about investments
Values about educator:	
Dedication and sacrifice	Teacher was at school despite being sick & had lost her voice.
Helpfulness	Walks around the classroom assisting learners
(Lack of) Good manners	Screams at learners & stamped her foot on the floor to get learners' attention
Values identified in the context of investments and loans	
Right action	By investing his money Bongani was able to increase his bank balance.
Discrimination (against Zandile)	Zandile had to pay more than was required for her medical operation (as compared to Bongani)
Values identified in the mathematical content	
Equality (sub-value of truth)	The use of the equal to sign:

Table 4: Values identified by focus group from video footage

CONCLUSION

The study has developed and validated a framework to interrogate how learners make sense of values in Mathematical Literacy lessons. Findings show that the learners found it easy to identify and talk about the values associated with the classroom environment. The fact that they were able to link an action to the value identified demonstrated their understanding. Although it did take the learners in the focus group a longer time to be able to identify values they thought were related to the content and context of the mathematics literacy lesson, they were able to do so quite effectively when they understood what was required of them. Using the framework will allow educators to ascertain whether their course materials provide the opportunity to sensitise students to the extensive social issues in their communities.

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