Exploring the notion of Mathematical Literacy

teacher knowledge

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Abstract
The introduction in South Africa of the subject Mathematical Literacy (ML) was an innovative response to the low levels of numeracy amongst adults. No other country has developed a subject with such an exclusive focus and this raises challenges for ML teacher educators to design a suitable curriculum to train ML teachers. In this article, the author first proposes a contextual attributes model of ML. Contextual attributes, such as contextual signifiers, language, rules and visual mediators, are identified and it is argued that ML learners require opportunities that facilitate engagement with these attributes in order to participate in the domains and make informed decisions. The author then explores some implications of this model for the conceptualisation of ML knowledge for teaching.

Keywords: Mathematical Literacy, teacher knowledge, pedagogical content knowledge, disciplinary learning, pedagogical learning

INTRODUCTION
One of the outcomes of the numerous school curriculum revisions has been a restructuring of learning opportunities in mathematics at the Grade 10–12 level. There has been much concern that so few learners have been involved in learning and applying mathematical skills beyond Grade 9 level. For example, in 2000–2005, as many as 40 per cent of all learners writing the matric examination did not take mathematics as a subject (Brombacher 2010). This concern about the low levels of numeracy in our adult population led to the introduction of the subject Mathematical Literacy (ML) as a fundamental subject in the Grade 10–12 band. Its purpose is not for learners to do more mathematics, but more application and to use mathematical skills to make sense of the world. Thus, for grades 10–12, all learners will do either mathematics or ML. The numbers of learners opting to study ML has increased since 2009 when 277 677 and 290 407 learners wrote ML and mathematics respectively. In 2012, the corresponding figures were 291 341 and 225 874 respectively (DoBE 2013). In terms of percentages, 44 per cent of learners studied ML in 2009 increasing to 56 per cent in 2012.

Considering the fact that there are more learners who study ML than those who study mathematics, it is crucial to interrogate the issue of teacher preparation...
for the subject. When the subject was introduced in 2006, there were no initial teacher education offerings for this specialisation, and most universities opted to offer in-service programmes for practise teachers who wanted to retrain as ML teachers. Since 2006, however, there have been a few higher education institutions (HEIs) which have designed and offered initial teacher education programmes with ML specialisations. There have been varying interpretations of the level of mathematics study that an ML teacher needs. Some HEIs have offered retraining programmes, such as the Advanced Certificate in Education where teachers need only mathematics up to Grade 9 level, while the Minimum Requirements for Teacher Education Qualification (MRTEQ) document, for example, specifies (for the Advanced Diploma in Teaching) that a person must have studied up to the National Qualification Framework (NQF) level 6 or 7 (university first or second year level) of the discipline. Another fuzzy issue is the role of contexts in ML and whether teachers need to have specialised content knowledge of the numerous contextual settings that are integrated within the subject. There are differing interpretations that have arisen from a lack of common understanding of ML, its role and purpose, and the similarities and differences between the subjects mathematics and ML. There have been some studies focused on the professional knowledge of ML teachers, but these have been mainly concerned with the teaching identities and knowledge of teachers (Hechter 2011; Nel 2012; Vilakazi 2010). However, much discussion and interrogation is needed of the kinds of curricula that could equip ML teachers to teach the subject in the way it is envisioned.

The preceding paragraphs point to the need for mathematics and ML researchers as well as curriculum designers to engage in more robust debate about the philosophy and role of ML and to identify teaching approaches which lead to successful implementation of the ML curriculum. In this article, I focus on the aforementioned issue by presenting one perspective of how the subject ML can be conceptualised and its positioning with respect to school mathematics and the contextual settings. This is done in order to look more deeply at the notion of teacher knowledge for ML teachers comprised of content knowledge and pedagogical content knowledge (PCK) that is embedded within the disciplinary learning and the pedagogical learning component in the MRTEQ document respectively (DHET 2011). I will use Sfard’s (2007, 2008) commognitive theory that views mathematics as a discourse together with Duranti and Goodwin’s (1992) notion of contextual attributes. Based on this perspective, I then discuss the implications for teacher preparation in ML, with a particular focus on the PCK of ML.

THE SUBJECT MATHEMATICAL LITERACY

ML was introduced in South Africa as a subject in the Further Education and Training (FET) band in a bid to improve the low levels of numeracy amongst the adult population. Its intention was not for learners to do more mathematics, but to enable them to participate meaningfully in decisions centred around various contexts
they encounter. A useful definition of numeracy (seen more broadly than just number sense) is: ‘The ability to access, use, interpret, and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life’ (PIAAC Numeracy expert group 2009).

Although this is a definition of numeracy it is relevant to mathematical literacy (as a competence). Note that the term mathematical literacy refers to a competence or skill while Mathematical Literacy (ML) refers to the school subject.

It is understood that in a world ‘awash with numbers’ and ‘drenched with data’ (Orrill 2001, xiv), any subject that is designed to help learners unpack such information, will need to include some mathematical elements. However, since the introduction of ML, there have been varying interpretations of what the subject is; what it is meant to achieve; and how it is meant to achieve the goals set out. There is a widespread view that ML is a watered down version of the real mathematics for those learners who cannot handle the real mathematics. Well-known academics have publicly criticised the introduction of ML as being a disastrous experiment because it does not allow learners access to pathways for careers in science or mathematics. (Child 2012; Jansen 2011). These interpretations presuppose that ML is about carrying out simple mathematics rules and procedures, which is a misconception.

According to curriculum documents, ML is described as:

The competencies developed through Mathematical Literacy allow individuals to make sense of, participate in and contribute to the twenty-first century world – a world characterised by numbers, numerically based arguments and data represented and misrepresented in a number of different ways. Such competencies include the ability to reason, make decisions, solve problems, manage resources, interpret information, schedule events and use and apply technology (DoBE 2011, 8).

This excerpt reveals that the intention is to allow learners to understand and utilise numerical or mathematically based information in real life situations. Venkat (2010, 55) remarks that ‘a life-preparation orientation, in which contextualisation in everyday-life situations is central, is a prevalent feature of the ML curriculum’. A curriculum that is aligned to these goals would develop learners’ skills at accessing, using, interpreting and critically assessing numerical information used in real-life contexts, and not just to work with mathematical rules and procedures.

PERSPECTIVES ON LEARNING

The nature and substance of what learning is and how it can be evidenced, occupies large fields of interest in research about education. The differing understandings of learning each generate such varying theories or degrees of interpretation that certain interpretations of different theories may overlap with one another. In fact the domains of application and assumptions of particular theories may be more relevant in certain
situations than others. For the current article, I draw upon the situated learning perspective – a broad set of understandings which conceptualise the learning process as changes in participation in socially organised activity (Lave 1988). Learning is located in learners’ increased access to participation rather than in the acquisition of structure, as is usually the intention in the case of mathematics. In drawing upon this perspective, I do not preclude other theories, such as constructivism, aspects of which may be appropriate at certain points.

Situative perspectives focus on the social and contextual nature of knowledge and emphasise the notion that much of what is learnt is specific to the situation in which it is learnt. An underlying assumption of the study is that much of what is learnt in ML is situated in various contextual domains. In keeping with the situative perspective, a conceptual domain in mathematics is viewed as an environment with resources at various places in the domain and knowing the domain includes the ability to recognise, find and use those resources productively (Greeno 1991, 175). This perspective implies that learning can be described as the increasingly skilled use of tools and resources in the domain.

Sfard (2007) asserts that learning mathematics involves increasing people’s participation levels in the discourse. The process of participating in a mathematics discourse involves creating narratives about objects in the new discourse. As people communicate with more experienced discursants, they begin to see how to use the elements of the new discourse appropriately. School mathematics as a discourse can be characterised by the use of mathematics signifiers (or mathematical words), visual mediators and routines in creating narratives which can be endorsed or rejected by more experienced discursants or interlocuters of mathematics (Sfard 2007).

Sfard (2008, 302) describes a signifier as a primary object used in communication. The use of mathematical signifiers (words) can reveal how the user sees the world. Sfard explains that in the process of becoming a participant of mathematical discourse, learners learn new uses of previously encountered words (eg, triangle, square) as well as new terms that they may not have encountered before but which are unique to mathematics (eg, negative 2 or negative one half).

Visual mediators are the means by which participants ‘identify the object of their talk and coordinate their communication’ and ‘mathematical discourses often involve symbolic artefacts, created specially for the sake of the particular communication’ (Sfard 2007, 573). Examples of visual mediators are graphs, drawings and diagrams.

Routines (rules) can be described as ‘well-defined repetitive patterns in interlocuter’s actions, characteristic of a given discourse’ (Sfard 2007, 573). Routines are not merely mathematical procedures, but include these.

A narrative is any ‘text, spoken or written that is framed as a description of objects or of relations between objects or activities with or by objects and that is subject to endorsement or rejection, that is, to being labelled true or false’ (Sfard 2007, 572). The process of participating in a mathematics discourse, involves creating narratives about objects in the new discourse.
**DOMAINS OF MATHEMATICAL LITERACY**

ML as a subject consists of an ‘elementary’ mathematics domain (DoBE 2011, 8) which is described as ‘those elementary mathematical concepts and skills that are relevant to making sense of numerically and statistically based scenarios faced in the everyday lives of individuals’. By taking note of the fact that all learners who enrol for ML have already engaged in mathematics up to Grade 9 level, it may be assumed that the elementary mathematics includes the use of the tools in those mathematics conceptual domains encountered at that level. Thus, learning ML involves participation in the elementary mathematics domain that was described using Sfard’s descriptors.

In addition to the elementary mathematics domains, ML also consists of domains different from the elementary mathematics conceptual domains. The curriculum documents specify that ‘in exploring and solving real-world problems, it is essential that the contexts learners are exposed to in this subject are authentic (ie, are drawn from genuine and realistic situations)’ (DoBE 2011, 8). Greeno’s (1991) description of conceptual domains can be extended to ML by taking contextual domains as environments with resources at various places in the domain, where knowing the domain involves the ability to recognise, find and use the resources.

I now draw upon Duranti and Goodwin’s work (1992) to elaborate on the resources or tools of a contextual domain. Duranti and Goodwin (1992, 2) comment that the function of the context is ‘to describe such circumstances that give meaning to words, phrases, and sentences’. They use the term ‘focal event’ to identify the phenomenon being contextualised:

> the focal event cannot be properly understood, interpreted appropriately, or described in a relevant fashion, unless one looks beyond the event itself to other phenomena (for example cultural setting, speech situation, shared background assumptions) within which the event is embedded (Duranti and Goodwin 1992, 3).

The context is thus a frame for the event being examined and provides resources for its appropriate interpretation. It involves two entities, namely: a focal event and a field of action within which the event is being embedded. I will use the phrase *contextual domain* to refer to the social and spatial setting within which the interactions take place (which has been described as the contextual setting by Duranti and Goodwin, 1992, 6).

Duranti and Goodwin (1992, 6–8) have identified the attributes of contexts (see also Bansilal and Debba 2012), which need to be attained in order to participate in the contextual domain.

Drawing from the work of Duranti and Goodwin (1992), I now outline four attributes that are essential for participation in a contextual domain.
1. *Contextual language* refers to the ways ‘in which talk itself invokes context and provides context for other talk’ (Duranti and Goodwin 1992, 7). In the current study, I use the phrase *contextual language* to refer to words or phrases which hold a particular meaning within the context, for example:

- ‘number of minutes more than 100’ (DoBE 2010, 4): This refers to the fact that the first 100 minutes used as part of a telephone contract are free and the person is only charged for the minutes accrued thereafter. This was given in an assessment task set around cellphone contracts;
- ‘mid-year population estimates’ (DoBE 2009, 5): This phrase clarifies the fact that the population figure, provided as part of an assessment task, was an estimation of the population in the middle of the year.

2. *Contextual signifiers* refer to the signifiers used in the context to convey specific information, and which have a meaning that is bounded by the parameters of the context, for example:

- Inflation rate signifier (DoBE 2010, 11): In the context of inflation, the figures reported as the annual inflation rate for the Consumer Price Index (CPI) need some unpacking. The process can be represented simplistically as follows:

\[
(I_1) = \text{inflation rate} = \frac{P_1 - P_0}{P_0} \times 100\%. \tag{1}
\]

Taking 6.15% as \(I_1\), as the monthly inflation rate for March 2012, this means that \(P_0\) and \(P_1\) represent the price levels in March 2011 and March 2012 respectively. (See Bansilal 2011 for a detailed discussion on this.)
- Gross Salary (DoBE 2010, 7): This refers to the ‘salary of a person before pension, tax, medical aid, etc. have been deducted’.

3. *Contextual rules* are bound to the context and need to be interpreted within the context by the learner, for example:

- In the example of the inflation signifier, the contextual rule is given by equation (1).
- ‘Total cost (in rand) = R150 + R0,50 \times (number of minutes more than 100)’ (DoBE 2010, 4): This rule is used to calculate the cost of a phone call within a cell phone package.

4. *Contextual visual mediators* refer to visual information presented in diagrammatic, graphical, symbolic, pictorial or other non-textual representation. An example of a contextual visual mediator (graph) showing the conviction rates for criminal complaints taken from a newspaper appears in Figure 1.
As is evident, this graph is used in a manner that is different from the typical ones encountered in a mathematics classroom. The graphs studied under the Functional Relations outcome in mathematics are usually described by a formula, and have a set of two axes and two variables where one is dependant on the second independent variable. In this case, the graph has a set of three axes, using three scales in an effort to emphasise the disparity between the number of recommended cases and the number of actual convictions.

Some of these attributes play a similar role as the discursive tools outlined in Sfards’ theory. The preceding discussion was intended to show that just as the conceptual domains in mathematics utilise discourses characterised by certain elements, so too can a contextual domain. Note too that the creation of context-specific narratives depends on the participant’s ability to use the contextual tools and resources appropriately. In the situation of the mathematics discourse, the narratives that are created centre around specified purposes such as finding the solution to given equations; describing the properties of the tools; or deriving general characteristics of these tools. However, in the contextual domain in ML, the attributes form a frame for the event being examined and the discourse is centred around appropriate interpretations of the focal event.

The contextual domains in ML have different and specialised resources that are appropriate within the parameters of the context and may be invalid or have no meaning out of the particular situation. Maton (2013, 46) uses the phrase ‘semantic gravity’ to denote ‘the degree to which meaning is dependant on its context’.
situation in which meaning is less (more) dependant on its context, is described as having weaker (stronger) semantic gravity. He explains that vertical discourse can be described as characterised by weaker semantic gravity than horizontal discourse. Contextual tools and resources thus have stronger semantic gravity, whereas the mathematical tools and resources have weaker semantic gravity. Maton (2013, 44) distinguishes between cumulative learning, where new knowledge builds upon and integrates past knowledge, and segmented learning where new ideas and skills develop alongside rather than building on past knowledge. Using Bernstein’s work, Maton (2013, 45) argues that ‘hierarchical knowledge structures develop through new knowledge integrating and subsuming previous knowledge, whereas horizontal knowledge structures develop through adding on another segmented approach or topic area’. Maton’s work raises questions for assumptions of trajectories of knowledge development in ML. A key issue on which ML teachers need guidance, is how they could enable cumulative learning in a situation where the meanings of the tools and resources have a very strong semantic gravity being rooted as they are in the context of operation.

**IMPLICATIONS OF THE CONTEXTUAL ATTRIBUTE MODEL FOR TEACHER KNOWLEDGE IN ML**

The Department of Higher Education and Training (DHET 2011, 11) gazetted a new qualification framework for teacher education qualifications which specified five types of learning ‘associated with the acquisition, integration and application of knowledge for teaching purposes’. In the current article, my focus is on the elaboration of disciplinary and pedagogical learning for teaching ML, since the other three are generic to all disciplines.

**Disciplinary learning**

*Disciplinary learning* consists of the ‘study of education and its foundations, including ... the philosophy, psychology ... and history of education’ and also includes ‘issues related to knowledge of, and relationships between the self and others’ (DHET 2011, 8). Thus, it can be seen that understanding the philosophical (and other) underpinnings of education as well as issues related to identity development of the teachers are located in this description. Furthermore, the document specifies that disciplinary learning also involves ‘the study of specific specialised subject matter’.

What is the content knowledge that is considered as specialised knowledge for ML? According to the Curriculum and Assessment Policy Statement (CAPS) document (DoBE 2011), ML knowledge includes knowledge of elementary mathematics content as well as knowledge of many contextual domains which are termed application topics. The earlier discussion has identified some of the demands associated with participation in the various domains. It has been shown that the mathematics domains can be characterised by the use of signifiers, visual mediators and routines, and that participation is dependant on the use of resources, such as
relevant mathematical language and mathematical reasoning, in order to use these tools efficiently. Specialised knowledge of ML will also involve specialised knowledge of the contextual domains. Issues around the knowledge of the mathematics domains and the contextual domains are unpacked further in the discussion that follows.

**Disciplinary learning related to elementary mathematics knowledge:** Any ML teacher should be prepared to facilitate the learning in the elementary mathematics domains that learners would have encountered by Grade 9. Some of the conceptual domains that are encompassed in this elementary mathematics include: rational numbers; basic algebraic routines such as factorisation, and solution of linear and quadratic equations; generalisation of patterns; measurement; space and shape; data handling; and some basic probability. It is thus incumbent that any ML teacher qualification should encompass the training required by a Senior Phase mathematics teacher, which requires sufficient disciplinary learning to teach mathematics at Senior Phase level.

**Disciplinary learning related to the contextual domains:** As outlined in the contextual attributes model, in order to understand the events under scrutiny in the contextual domains, students need to attain the attributes of the contexts, including the contextual signifiers, rules and visual mediators. In a study by the author (Bansilal 2011) about teachers’ engagement with the inflation rate signifier, it was found that some teachers displayed a deep, sophisticated understanding of the contextual signifier and the underlying contextual routines. This enabled them to make inferences about trends in movements in price levels, when given information about inflation figures. On the other hand, many teachers displayed a superficial understanding of the quantities and ‘had trouble distinguishing between movements in the inflation rate and movements in the price of goods because consecutive drops in the inflation rate [were] interpreted as a drop in the price of goods’ (Bansilal 2011, 180).

A study by Bansilal, Mkhwanazi and Mahlabela (2012) based on the contextual rule of transfer duty, found that the teachers displayed varying levels of engagement. It was found that 81 per cent of the teachers were able to calculate the duty when the house price was given, demonstrating that the majority were able to use the rule in a direct manner (given the house price, calculate the duty). However, only 55 per cent were able to handle the rule in a more mathematically sophisticated manner when the question was changed (given the duty paid, find the house price). These studies suggest that teachers need a deep understanding of the contextual domains that are included in ML, such as income tax, bond costs, health issues, exchange rates, maps, scale drawing, statistics, and so on. Although it is impossible for teachers to be introduced to all the contextual domains, any teacher education programme must include a focus on those contextual domains prioritised in the curriculum documents.

**Disciplinary learning related to the history and philosophy of ML:** An additional aspect required by an ML specialist in this aspect of learning, is that of understanding the philosophy, sociology and history relating to the introduction of ML. The introduction of ML was underpinned by a strong and critical social justice
Exploring the notion of Mathematical Literacy teacher knowledge

perspective, because the subject was intended to empower learners to make informed decisions about issues they encounter in their world. Therefore, a crucial aspect of any teacher learning should be the provision of opportunities for teachers to construct an understanding of the guiding philosophy behind ML, and to also ensure that they can differentiate between ML as a subject in its own right instead of seeing it as the poor relative of the subject mathematics.

Disciplinary learning related to identity development: An essential aspect of the disciplinary learning required is that of providing opportunities for identity construction that are compatible with the aims of ML. Nel (2012) conducted a study with practising ML teachers to explore the ways in which their identities shifted as they participated in an in-service qualification programme. The identity that evolved within teachers in Nel’s (2012, 152) study emerged beyond the classroom, to the extent where teachers saw themselves as leaders in the field of ML, and Nel offered three possible categories of identity shifts:

• teachers whose previous identities moved to the background and their ML identities to the foreground;
• teachers who added their ML identity to their existing identity, leaving them with a dual identity: the one they had before their involvement in the ACE ML programme and the ML identity;
• teachers whose identity before the ACE ML programme was maintained, while their ML identity was still developing.

Nel’s study was based on practising teachers who were enrolled in an in-service course. For initial teacher training, the process of identity development may be different from these teachers, or perhaps it could be similar. Further research that can contribute to knowledge about the demands of the transition is urgently needed. With a subject like ML, which has a strong social justice orientation, it is essential that the curriculum provides space for growth opportunities for teachers, as well as research opportunities to inform the curriculum development.

Pedagogical learning

The MRTEQ document describes pedagogical learning as including

knowledge of learners, learning, curriculum, and general instructional and assessment strategies; and specialised pedagogical content knowledge [PCK], which includes how to represent the concepts, methods and rules of a discipline in order to create appropriate learning opportunities (DHET 2011, 8).

In this section, I focus on PCK related to knowledge of the mathematics and contextual domains.

PCK related to mathematics: An ML teacher will be teaching learners who have studied mathematics up to Grade 9 level, many of whom have chosen to discontinue their studies in mathematics. They may have had varying levels of success and may
have developed conceptions of their own, which could be correct or sometimes incompatible with existing mathematics discourses. The ML teacher will therefore need to able facilitate further learning with these learners. Thus, an ML teacher needs the opportunity to develop PCK in the elementary mathematics domain. PCK is described by Shulman (1986, 9) as the:

... subject matter knowledge for teaching ... the ways of representing and formulating the subject that make it comprehensible to others ... [It] includes an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages bring with them to the learning of those most frequently taught topics and lessons.

Furthermore, a teacher needs to understand that in an inquiry-orientated classroom, the teacher’s task as suggested by Prawat (1989) is to create conditions that allow learners to develop structures that are both powerful and robust. Cobb, Yackel and Woods (1993) agree that a good teacher must be skilful at posing questions; listening carefully to students’ ideas; rephrasing students’ explanations in terms that are mathematically more sophisticated; deciding when to provide information; and orchestrating class discussions to ensure participation by all students. Thus, teachers will need to be provided with opportunities that allow them to develop such skills.

PCK related to contextual domains: Similarly, there will be PCK linked to the contextual attributes of the contextual domains. Borrowing from Shulman’s (1986) description, teachers also need to have knowledge of the contextual domain for teaching, which includes ways of representing the various contextual rules and signifiers that make it comprehensible to others; and an understanding of what makes specific contextual rules, signifiers and visual mediators easy or difficult. In addition, PCK of the contextual domains will include an understanding of the conceptions and experiences that learners bring with them to the ML classroom. Teachers need to understand the demands of solving problems set within various contexts. Working with ML tasks is not a simple matter of applying mathematical knowledge and rules to a new situation, it also involves attaining the various attributes of the context. In order to engage in tasks set within such contexts, learners must be able to access the meaning of the contextual language that is being used, and must also access, interpret and use the context-specific signifiers, routines and visual mediators that operate in the context. This means that teachers must help learners to develop skills in recognising and identifying these contextual tools, and provide opportunities for learners to communicate using the rules, signifiers and visual mediators of the contexts.

PCK related to task design: Contexts which help learners to understand some of the complexities of decision making in real life, are crucial tools in trying to achieve the mandate of ML in South Africa, and tasks which are able to capture some of these complexities are important tools in ML. Thus, a key competence of ML teachers is the ability to design suitable, relevant and meaningful tasks which can contribute to
this end. Because of the strong social justice perspective of ML, it is incumbent on
the teachers to provide learners with opportunities to critically assess issues that they
face individually and in their community. An associated demand on ML teachers is
therefore the need to produce clear, and unambiguous tasks which allow learners to
investigate issues that they encounter – in a bid to cast light on outstanding, unfair or
discriminatory practices prevalent in the school, community, municipality, country
or globally. Figure 2 is a reproduction of a task produced by an ML teacher based on
grasscutting costs, illustrating how he has used an everyday situation to derive a task
that can be used to make a judgement.

The task in Figure 2 was designed by a teacher who recognised an everyday
situation that could be used to pose a problem. Notice how much information was
required before the questions could be posed. The information about the units
of measurement, the different rules for the patches of different shapes, and the
information about calculating the area of different shapes is what is referred to as
crucial information, without which the task cannot be solved (Bansilal and Wallace
2008). The initial information about the background is just contextual information
which is used to paint the picture. The contextual signifier in this task is the 10-stride
square which forms a unit of area. The contextual rules are the rates for the different
shapes.

With respect to task design in ML, an important issue is the presentation of crucial
information that conveys the meaning of context-specific terms, signifiers and rules.
Debba (2011) found in one ML examination paper that all 73 learners misunderstood
a contextual signifier appearing in the task, although the description was provided.
When interviewed, learners said they missed the information because it appeared too
early, nine sub-questions ahead of where it was needed. Other reasons identified in
research about why learners miss the crucial information is that the explanation was
too dense to understand or it was missed amongst the overload of other extraneous
contextual information (Bansilal and Wallace 2008). It thus behoves an ML teacher
to ensure that crucial information about contextual attributes is presented as simply
and as clearly as possible.

A study by Moodaly (2010) with a group of 32 ML teachers who were asked to
design an activity for ML learners, found that they all struggled with the design.
Moodaly’s (2010) findings were that 84 per cent of the activities were below the
grade level specified. There were 29 per cent of the teachers that had incorrect
solutions to their tasks, while 12 per cent had irrelevant answers. This study showed
that the teachers were not well-equipped to design suitable tasks for ML learners.
This suggests that teacher educators need to focus on developing skills in designing
tasks.
Bansilal

Benny: The clever grass cutter who makes money while the sun shines!!!

Benny is a grass cutter who charges a fee to cut grass which may be of different heights. He uses his foot, ankle and knee for measurement. This unique and practical method of measurement determines the price you pay for his grass cutting service. Let us now bring the maths in practice from outside into our classroom.

Let’s revise the formulae for area first.

Area of a square = \( s \times s \)
Area of a rectangle = \( l \times b \)
Area of a triangle = \( \frac{1}{2} b \times h \)
Area of a circle = \( \pi r^2 \)

Benny uses his ‘feet a stride place’ to measure distance (which could be the length, breadth, diameter or base of a triangle). He uses his ankle and knee for the height of the grass/shrub. This is how he determines a price for his service:

**SQUARE PATCHES OF GRASS**
- For square areas, he requires a minimum of 10 strides for each side of the square. (For smaller squares he charges as for a 10-stride square.)
- If the grass is ankle high, he charges R50 per square of 10 strides.
- If the grass is knee high, he charges R100 per square of 10 strides.
- If the grass is above knee height, he charges R120 per square of 10 strides.

**CIRCULAR PATCHES**
- He measures the diameter and then charges as he would for a square of 10 strides.

**TRIANGULAR PATCHES**
- He measures the base of a triangle and charges it at half the price that he would for a square with that length.

Questions:
1. Calculate in cm:
   a) the length of your stride
   b) the height of your ankle
   c) the height of your knee
   d) the height of your leg
2. Consider grass that is just ankle high. Investigate which shape of the grass patch is a better deal for Benny.
3. Now investigate which height of the shape you mentioned in Question 2 above, would be a better deal for Benny.

Figure 2: Grasscutting task (Juganandan 2012)

**PCK related to assessment skills:** Any assessment must be guided by an understanding of how progression in learning can be recognised. However, ML curriculum developers need to first tighten the curriculum descriptors of progression in ML
Exploring the notion of Mathematical Literacy teacher knowledge

The ML assessment taxonomy which distinguishes between four levels of understanding in ML has received some criticism (Bansilal et al 2012; Venkat, Graven, Lampen and Nalube 2009). There is little direction of how contexts can become more complex, except for the simplistic and unhelpful distinction between familiar and unfamiliar contexts. Venkat et al (2009, 49) write that ‘the emphasis appears to be on mathematically focused progression within’, revealing that progression in ML complexity is often conflated with progression in mathematical complexity. In fact the names of the levels in the two taxonomies (mathematics and ML) are very similar and signal the perceived close alignment of ML with mathematics. This perception may block a recognition that the rules and other tools of the context are often different from those in the mathematics domain.

One aspect of complexity of a context can be explained by the complexity of the underlying rules, signifiers and visual mediators operating in the focal event under consideration. This is a more nuanced understanding of context complexity than the one which conflates context complexity with the degree of familiarity of the context. The implications for developing PCK of ML teachers is that teachers themselves must be given opportunities to work with contexts of different complexity and to overtly discuss how treatment of the tools of contexts can be organised and sequenced in an ML classroom.

North (2010), in his analysis of the 2008 Grade 12 Mathematical Literacy Examination paper, found that it did not adhere to the stipulations of the DoE assessment documents in terms of content coverage and cognitive difficulty. Assessment of several topics, such as inflation, taxation, quartiles, percentiles, and graphs with negative axes, were completely omitted. The unbalanced distribution of marks according to the taxonomy levels, where a low percentage of marks were allocated to level 4 and a high percentage of marks allocated to level 2 questions, resulted in the examination assessment becoming cognitively less demanding. This contributed to a false impression of the high pass rate in the subject in 2008. In his analysis, North (2010, 12) also found many of the contexts used were ‘pseudo-contexts’. They were contexts that were either artificially constructed; inappropriate to the mathematics being explored in that context; or refocused to draw attention to specific mathematical concepts and away from real-life situations. The results of North’s study (2010) show that there is a need for stakeholders to examine these issues more closely. The implication for teacher educators is that the programmes must create opportunities for prospective teachers to engage with these issues during their training.

CONCLUDING REMARKS

In the current article, I have looked at how the notions of disciplinary learning and pedagogical learning could be interpreted for the subject of ML, which is a new development in South Africa, actually in the world. No other country has developed a subject with such an exclusive focus. It is therefore challenging for ML teacher
educators to design a curriculum that could help to produce ‘the kinds of teachers’ the country needs for ML (DHET 2011, 4). For a subject in its infancy, much research, discussion, as well as reflections from experience need to take place before a common understanding can be reached of what the nature of ML is.

The article was meant to contribute to the discussion by proposing a contextual attributes model of ML. In this model, some contextual attributes are identified and it is argued that ML learners require opportunities that facilitate engagement with these attributes in order to participate in the domains and make informed decisions. The focus of the article was thus to identify some implications for the conceptualisation of, disciplinary learning and pedagogical learning with regards to the preparation of ML teachers. By foregrounding the notion of context and identifying the actual contextual attributes, the issue of how the life preparation mandate of ML could be emphasised was discussed.

I have argued that disciplinary learning and pedagogical learning in ML should encompass the disciplinary and pedagogical learning envisaged for a Senior Phase mathematics teacher. In addition, disciplinary and pedagogical learning for ML teachers should include opportunities for deep engagement with the contextual attributes of the contextual domains, and the history and philosophy of ML. Pedagogical learning should also prioritise the development of skills in task design and assessment, that should be underpinned by a clear idea of how progression of learning in ML could be traced.

At issue here, as in any educational setting, is also the question of what the features of an ML teacher education curriculum that enables cumulative learning, could be like. Teacher educators are at the stage of interrogating possible curricula; however, there is still a long way to go and they need to be alert to certain issues. Maton (2013) found in his study of two curriculum structures in language and a professional education course, that although both claimed to enable higher order learning capable of application in new contexts, both offered minimal guidance on these principles. Maton (2013) cautions that one feature of educational knowledge that may constrain the development of cumulative knowledge is the attempt to achieve these higher order knowledge outcomes using learners’ dispositions, aptitudes and attitudes as a means, constituting a mismatch. This is a caution that is particularly relevant to the subject of ML with its emphasis on developing critical citizens, which can so easily end up as rhetoric that is not translated into practice.

It is hoped that the article may lead to further debates in the field about what should be foregrounded in teacher education programmes for ML. Perhaps the ideas presented here may spur other ML researchers to extend them further; to refute them; or to make available alternate conceptualisations. These discussions, arguments, refutations, support or extensions to current ideas will help move forward the current understanding of how teachers could help to fulfil the life preparation mandate of ML; how teacher educators could develop programmes to help teachers meet that need; and whether in fact the goals of ML are within reach of South Africa’s educational system, or whether they are destined to remain as rhetoric.
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