TENSIONS BETWEEN CONTEXT AND CONTENT IN A QUANTITATIVE LITERACY COURSE AT UNIVERSITY

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We present our views on the purposes and nature of quantitative literacy and our position on the relationship between mathematical and statistical content and disciplinary contexts in a quantitative literacy course for university students in humanities and law. We locate these views in the existing literature. We discuss some of the tensions we experience in our teaching, which challenge our assumptions about the appropriate balance between contexts and content in our 'context-driven' curriculum. We use preliminary observations to highlight some of these challenges and use these to suggest questions for further study.

INTRODUCTION

The important role of quantitative literacy [1] in higher education curricula is increasingly being recognized internationally (for example, Yasukawa, 2007; Steen, 2004). Yet the quantitative demands of academic disciplines in higher education, for example in law and humanities, are often very different from those that are the focus of traditional mathematics courses. Completion of mathematics courses does not guarantee quantitative literacy (Hughes-Hallet, 2001).

Many students in South Africa are poorly prepared to meet the quantitative literacy (QL) requirements in university curricula (Frith and Prince, 2009). There is a lack of articulation between the demands of the university curriculum and students' experiences of school mathematics, as well as enduring inequalities in the education system. The aim of the Academic Development Programme, of which we in the Numeracy Centre are a part, is to address this articulation gap and work towards equity of access to (and outcomes in) university study at the University of Cape Town.

Though our primary aim is to equip students to deal with the complex quantitative demands of their studies in higher education, our location at a higher education institution in the new democracy of South Africa, as well as our personal histories, leads to our work also being driven by a concern for social justice and a firm belief that our students should be functioning, yet critical, citizens.

In this paper we are specifically referring to our experiences in 'stand-alone' courses designed for first-year humanities and law students [2]. In 2009 we began a reform process in these courses, with the aim of shifting the curriculum from what Graven and Venkat (2007, p.74) would call "mainly content-driven" to "context-driven". We begin by locating our views on the purposes of QL in the existing literature. This provides a frame for our position on the relationship between mathematics content and disciplinary contexts, and the related decisions about curriculum. We then draw

on our initial research into our curriculum reform process to discuss the tensions that arose in our teaching due to the assumptions we have made about the role of contexts in our QL curriculum.

WHAT DOES IT MEAN TO BE QUANTITATIVELY LITERATE?

We conceptualise quantitative literacy as practices imbedded in particular social (and academic disciplinary) contexts. We also subscribe to Johnston's (2007, p.54) view that numeracy is "a critical awareness that builds bridges between mathematics and the real world". Quantitative literacy can be described in terms of the contexts, the mathematical and statistical content and the behaviours and reasoning that are involved in quantitatively literate practice (Frith & Prince, 2009). Accordingly, we have adopted the following definition:

> "Quantitative literacy is the ability to manage situations or solve problems in practice, and involves responding to quantitative (mathematical and statistical) information that may be presented verbally, visually, in tabular or symbolic form. It requires the activation of enabling knowledge and behaviours and can be observed when it is expressed in the form of a communication, in written, oral or visual mode." [3]

The development of this definition was most strongly influenced by the definition of numerate behaviour underlying the assessment of numeracy in the ALL survey (Gal et al, 2005) and the view of literacy as social practice (for example, Street, 2005).

PURPOSES OF QUANTITATIVE LITERACY IN HIGHER EDUCATION

In Table 1 we summarise the relationships between our purposes and some different classifications from the literature (the various authors' own choices of terms are used). The Numeracy Centre has an established view on the purpose of developing our students' QL, which can be explained by our location in a higher education institution in South Africa in the first decades after the abolition of apartheid.

Our work has been driven by three main purposes. First, the centre exists at the institution to assist students with the quantitative demands of their chosen discipline with a view to their future careers (in Table 1, categories 'tertiary study' and 'professional life and work'). Secondly, our work is driven by a social justice agenda in which we strive to sensitize students to the extensive social problems in our country (in Table 1, 'social justice' category). Lastly, we aim to equip students to become functioning citizens of the country. This goal has two elements, which we describe as 'everyday life' and 'citizenship' in Table 1 and which differ in the degree to which they have to do with the individual's engagement with society in their personal capacity.

Numeracy Centre, UCT *Purposes for Quantitative literacy:*	Jablonka, 2003 *Ingredients of Mathematical Literacy*	Gal et al, 2005 (ALL framework). *Purposes and goals for Numeracy*	Steen, 2001 *Expressions of quantitative literacy*	Yasukawa et al, 2008 (quoting Schuller) *Benefits of learning*	S A school subject "Mathematical Literacy", 2003. *Purpose of the subject*
Tertiary study	Developing human capital	Further learning	Education	Human capital	
Professional life and work		Work-related	Professions		Workplace
			Work		
Everyday life		Everyday life	Personal finance		Everyday life
			Personal Health		
Citizenship		Societal or community	Citizenship	Societal capital	Citizenship
Social justice	Social change				
	Environmental awareness				
	Cultural identity			Identity capital	
	Evaluating mathematics				
			Management		
			Culture		

Table 1: Some classification of the purposes for quantitative literacy

CONTENT AND DISCIPLINARY CONTEXT IN A QUANTITATIVE LITERACY CURRICULUM

The most important characteristic of quantitative literacy in the higher education curriculum is that it is situated in the contexts and disciplines where it is practiced (Steen, 2004). For a competent practitioner in a discipline the mathematical content is often dealt with so fluently that it is relatively "transparent" (Lave and Wenger, 1991, p.102), in the sense that the mathematical content becomes invisible and does not present any obstacles to the engagement with the context. The practitioner of QL in a particular discipline must simultaneously deal with mathematics concepts and the concepts of the context in which they are operating.

Consider a very simple example: A report in a South African newspaper in July 2009 said that striking construction workers (building 2010 Football World Cup infrastructure) settled for a 12% pay rise. To understand what this really means in the social context, you need to know that the average daily wage of a construction worker is R140 (context), to be able to accurately calculate 12% of R140 and to realise that this calculation would be useful (mathematical content). To assess the meaning of calculated quantity in the social context of the workers, you need to understand something about prices, the inflation rate, the average number of dependants a worker has and so forth (the context). Now you might feel that to derive greater insight you need to recalculate the daily wage figures as annual income so that you can make a comparison with salaries of workers in other sectors more easily, in which case the context will be dictating what mathematics to do. So even the process of interpreting a simple quantitative statement can lead to fairly complex trains of thought involving mathematical competencies applied in an integrated way within one's thinking about a particular real context.

Our role as QL lecturers is to ensure that students know when and how to do the necessary mathematics within a given disciplinary context, which is only possible if students have an understanding of the context itself. This presents challenges for our course design.

The first challenge relates to the choice of contexts. Zevenbergen, Sullivan and Mousley (2002) point out how contextualisation of mathematics in unfamiliar contexts can create barriers to students' learning. However if we use contexts familiar to students, this could compromise our goal of sensitising students to social issues in society. If we use contexts that students are not familiar with, we may be overloading them with having to learn about the mathematics and the features of the context at the same time, at the risk of letting the mathematics be submerged. Given our experience that our students have significant difficulties with the required mathematical and statistical content, they cannot afford to spend much of the course time on learning about the features of specific contexts. Furthermore, the choice of contextual material is also determined by the availability of suitable authentic material in which the

necessary mathematical and statistical content topics are embedded. Jablonka (2003) highlights the difficulty of finding contexts that are exemplary in terms of social and political relevance but also exemplary in terms of the practices of mathematics.

The second challenge relates to achieving an appropriate balance between context and content in the curriculum. Graven and Venkat (2007) present the possibilities as a spectrum of approaches to the balance between content and context, as well as some of the associated tensions, for example aiming for authenticity of the context as well as mathematical understanding. In our practice at the most general level, it entails a choice between a 'content-driven' curriculum and a 'context-driven' one. In both cases the development of the mathematical and statistical knowledge and techniques and their appropriate use is our major goal. For many years (for pragmatic reasons) the underlying organisation principle of our course has been the mathematics and statistics content, which we always presented using relevant contexts. This would correspond to what Graven and Venkat (2007, p.74) characterise as "mainly content-driven".

Our belief has always been that ideally we should strive for a higher degree of contextualisation, where students would engage with substantial real contexts, and the necessary mathematics and statistics would arise and be developed as needed. In Graven and Venkat's (2007, p.74) terms this would be a "context driven" curriculum. The motivation for this is that it more closely mimics the reality of the practice of QL in the disciplines; our assumption being that similarity between the features of the context selected for the stand-alone QL course and of the disciplinary context will enhance transfer of what students learn in our courses to their practice in the disciplines. We believe that it is a similar assumption that underlies all arguments in favour of teaching QL in context (for example Steen, 2001, 2004; Department of Education, 2003).

TENSIONS ARISING ON IMPLEMENTING THE CURRICULUM

In accordance with our belief that the curriculum should be context-driven, in 2009 we structured the first part of our curriculum for humanities and law students around three contexts: a module on children's rights, a module on xenophobia and one on prison overcrowding (rather than having modules built around different categories of mathematical content, which is the structure we retained for the second half of the course covering financial mathematics and statistics). We present students with edited extracts from research reports of the kind which we believe they will encounter in their disciplinary studies. The extracts are accompanied by comprehension-type questions which are used as a basis for workshops in which students are assisted in making sense of the quantitative information presented in the contextual material.

In order to study the curriculum reform process, we collected data on lecturers' and students' experiences. This data is in the form of field notes from classroom observations, annotated lecture notes, audio-recordings of the weekly staff meeting

where the courses were discussed, three focus group interviews with students and copies of students' work.

A number of tensions experienced by lecturers and students when implementing this kind of curriculum in 2009 have led us to question our assumptions about the degree to which the curriculum should be driven by the contexts studied. We discuss these below, and draw on preliminary data from our study as illustration.

Achieving a balance between content and context

Our decision to emphasise contexts presented challenges in terms of classroom practice. Firstly students were less familiar with some of the concepts and terminology associated with the contexts than we expected they would be. The additional activities designed to improve their understanding of the contexts affected the pace at which we were able to work through the tasks, something that the students identified in interviews, for example: "I felt like … we drew it out for a very long period of time". Classroom discussion of the contexts also highlighted for us differences between our own understandings of the country's history and those of our students who have grown up in post-apartheid South Africa. Reflecting on discussions in her class about the need for an act of law to resolve backlogs in social services, one lecturer commented, "you forget … they don't realise that there was this momentous thing that happened in 1994 and things were <u>completely</u> different".

The second challenge relates to the depth at which students engaged with the contexts. Those students we interviewed clearly appreciated the fact that the material was current, felt that it had relevance to their lives, as opposed to what they had experienced before in school: "Like in school they just give you like fabricated stuff, like made up things, but a lot of the stuff was real and relevant to South Africa like with xenophobia". Yet we were disappointed that many students did not engage with the contexts in the critical manner that we had envisaged. For example we aimed to highlight the denial of human rights of prisoners (especially the considerable numbers of awaiting trial prisoners) in overcrowded prisons, but many students voiced unconsidered views that anyone in jail deserved bad treatment.

Our original teaching plan included a weekly 'summary lecture' in which we would review the mathematical content and link this to its use in context. However, these fell away as we spent more time dealing with the contexts. As lecturers we became increasingly concerned that the mathematical content was being eclipsed in favour of the context, for example the following was voiced in a staff meeting:

> "I'm feeling concerned about the discomfort that students are feeling … I think we need to give them some structured framework they can slot the content into. … I'm kind of wanting to stop and say, "Hey now this is what we've done. All of these questions let's go and look at them. This is percentage increase, or percentage change, these are percentage points.""

Students' responses to the materials suggest, too, that they were not engaging with the content in sufficient depth. For example, a student expanded on his view that the materials were tedious by identifying the content quite generally as "percentage change": "But this was almost like percentage change, then percentage change within prisons and then with xenophobia". However, formal assessments suggested to us that the students were not distinguishing between different types of percentage change calculations or identifying when appropriate kinds of calculations were needed.

Students' confusion about the nature of what they were learning and what was valued in the course

As we attempted to balance the content and contexts in our practice, we sensed discomfort on the part of our students. Students had expectations of the course, often based on their experience of school mathematics, for example, "Please can you tell us what formulas we've done". But they were also confused about what they were learning; when preparing for the first assessment which occurred when the context was children's rights, a student queried whether it was necessary to learn the details of the relevant act of law. This kind of confusion, particularly for disadvantaged students, is similar to that identified by Zevenbergen et al. (2002).

We also recognised that we were expecting students to engage with the contexts in different ways in different circumstances. During class discussions of the social contexts, we encouraged students to draw on their personal experiences. Yet our assessments valued arguments that were substantiated with data and calculations. Although it was not rewarded, some students continued to ground their arguments in their personal experiences, often not recognising subtle textual clues as to what was required.

Concerns about transfer

We do not at present have solid evidence that the knowledge and ways of thinking we are trying to promote in the context-driven curriculum will be transferred to the disciplinary practices elsewhere in the students' curriculum or in a profession. This lack of evidence is due both to our concern about selecting an appropriate methodology for researching the concept of transfer, and to the practical limitations on our ability to collect evidence. It is a matter of concern, therefore, that we are basing our curriculum choices on a fundamentally untested assumption about transfer, and responses of past and present students to our courses serve to highlight our concerns. For example, a psychology graduate, who experienced the previous content-driven curriculum, expressed the opinion that she was able to use her learning in the QL course in subsequent years, "I attribute my current knowledge and ability to grasp statistics to this course". It is possible that the structuring of knowledge in our course around specific statistical concepts facilitated the transfer of this knowledge in subsequent courses which also highlighted the same content topics. This observation

does not support our assumption that a context-driven curriculum is the most effective in promoting transfer.

Furthermore, our observations of and discussions with students who studied the new context-driven curriculum suggest that many still view the course as a "mathematics" course. These perceptions serve as a reminder that the context selected for curriculum material cannot be viewed in isolation from the wider social setting, that is, a course that is coded by the institution as a mathematics course. Students will use their perceptions of the broader setting of the course to make a "negotiated judgement" of the context (Evans, 2000, p.85), and this judgement may have implications for the successful transfer of practices to other settings.

Impact of using language-based texts

Students characterised the course as having particular "writing" and "explaining" requirements. Those students interviewed identified that the course valued a particular way of writing; for example: "… there were times we would write a paragraph and I'd write what I thought … and all the information I gave was information I'd gotten from the data, but then they'd just be looking for something different".

The interviewed students could recognise and articulate the differences between school mathematics and the QL presented in the course. Yet our observations suggest that students still approached the context-based material rather like school mathematical word problems. They identified cues in the text for how to proceed rather than using the text as a resource to identify an appropriate strategy.

Many students attributed their difficulties to their view that the questions were not "clear", yet we identified the problems as deeper, and related to the complex demands of balancing content and context in QL practice. For example, presented with a table of data on prisoners for three different years, students were asked to, "Draw up a table that shows the total (absolute) number of unsentenced prisoners and the number of unsentenced prisoners as a percentage of the total (relative number) for each of the three years". In order to establish what is required by this task students must identify meaningful parts of this sentence, for example, "for each of the three years", but also hold the whole sentence in view. In addition, to complete this task students need to work with and across tabular and textual representations.

In this section we have identified some of the difficulties students encountered when working with language-based texts. These highlight the need to find a way to provide the necessary language support, particularly for students for whom English is not the home language. We have established an ongoing collaboration with an academic literacies specialist to assist us in this regard.

CONCLUDING REMARKS

In changing from a content-driven to a context-driven curriculum in a QL course for students at university, we believed we would achieve our purposes and serve our students' needs more appropriately. The experience of implementation has caused us

to question some of the assumptions we made about the balance between context and content in such a curriculum. This discussion of the tensions we have experienced is based on our preliminary observations during our first experience of our newly-structured curriculum. It raises the questions that concern us, rather than attempting to present arguments for changes that will resolve these questions. We regard these questions as indicating the areas for further research which will point the way to achieving a more effective quantitative literacy curriculum.

Specifically, the questions can be summarised as:

What interventions will be effective in ensuring that students have a clear idea of the objectives of the course, in terms of the relative importance of content and context?

What balance between context and content is optimal (and how should these be related in the course) to maximise students' ability to transfer what they have learned to new situations?

What interventions will be effective in supporting students' reading and writing in a language-based quantitative literacy curriculum?

NOTES

1. The terms quantitative literacy, numeracy and mathematical literacy are often used interchangeably when naming a wide range of practices related to dealing with quantitative information. We prefer the term 'quantitative literacy', since in South Africa, 'Mathematical Literacy' is the name of a school subject and 'numeracy' is most often associated with learning in the early stages of a child's schooling. However the term 'numeracy' means the same as 'quantitative literacy' (often referred to as QL) in this paper.

2. Given the context-bound nature of QL practice, we do not advocate separate QL courses as the optimal kind of intervention, although for structural reasons they are sometimes the best choice. The fact that our teaching of QL is separated from the disciplinary practice in this way leads to many of the tensions we experience.

3. A detailed summary of our view on what a student needs to be able to do in order to practice QL is given in Frith and Prince (2009).

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