

A quantitative literacy course for Humanities and Law students: The challenges of a context-based curriculum

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This article examines some aspects of the effectiveness of a first-year course in quantitative literacy for Humanities and Law students at a South African university. This intervention is necessary to assist students in developing the appropriate quantitative competencies because there is an articulation gap between the quantitative literacy of many first-year students and the demands of their curriculum in this regard. Interventions of this kind should be integrated into the disciplinary curriculum to as great an extent as possible, primarily because quantitative literacy is a practice embedded in the disciplinary practices. Tensions involved in attempting this integration limit the course's effectiveness and are to a large extent due to the conflicting demands on students of both the disciplinary discourses and the mathematical and statistical content. The intervention could be enhanced by being more explicit in clarifying the distinctions between the disciplinary contexts and the mathematical and statistical content, as well as by making more explicit the expectations in terms of student learning and performance in assessments.

Keywords: Quantitative literacy, numeracy, quantitative literacy course, curriculum, higher education, humanities, law, disciplinary discourse, quantitative literacy practice, mathematical content

Introduction

The importance of quantitative literacy (also known as numeracy) for higher education is recognised internationally (Chapman, 1998; Yasukawa, 2007; Steen, 2004). There is an increasing recognition that many academic disciplines make complex quantitative demands on students in higher education, even those such as Law and Humanities, which are not obviously quantitative in nature. The quantitative demands of these disciplines in higher education are often very different from those that are the focus of traditional mathematics courses. Thus, completion of mathematics courses does not guarantee quantitative literacy (Hughes-Hallet, 2001:93).

Many students in South Africa are poorly prepared to meet the quantitative literacy requirements in university curricula (Frith & Prince, 2009:83). This assertion is supported by results from the National Benchmark Tests Project. For example, in the pilot tests in 2009 only one quarter of all students tested were classified as “proficient” (Yeld, 2009:79) in quantitative literacy. Curriculum interventions are needed to reduce the “articulation gap” (Scott, Yeld & Henry, 2005:273) between the demands of curricula and the level of many students’ quantitative (and other) literacies. A major aim of our work in the Numeracy Centre at the University of Cape Town is to address the articulation gap so as to improve equity of outcomes in university study.

As with the literature dealing with teaching and learning of Mathematical Literacy at the school level (for example, Christiansen, 2006; Graven & Venkat, 2007), the South African literature on quantitative literacy in higher education is limited (see, for example, Brink, 2001; Archer, Frith & Prince, 2002; Prince, Frith & Jaftha, 2004; Prince & Archer, 2008). The discussion in this article is presented as an attempt to stimulate more research and debate about quantitative literacy in higher education. I will focus on factors limiting the effectiveness of a first-semester course for Humanities and Law students, which is developed and taught collaboratively, so that much of what I write is a reflection on the communal efforts of Numeracy Centre staff.

I will begin by discussing what I mean by the term quantitative literacy and describe the context of the course described in this article. I will then consider some observations regarding the implementation

of the course curriculum, focusing on some factors that limit its effectiveness in achieving our curriculum goals.

Defining quantitative literacy

My conceptualisation of quantitative literacy rests on Gee's (1990:151) notion of secondary Discourse and the approach of the 'New Literacy Studies' (Gee, 1990:49) which views all literacies as social practice. Gee (1990:xvii) introduced the notion of "Discourses" as demanding "certain ways of using language, certain ways of acting and interacting, and the display of certain values and attitudes". He pointed out that there are specific different Discourses associated with different "subject matters", or academic disciplines, and characterised these as examples of "secondary Discourses" (Gee, 1990:151). He then defined literacy as "mastery of, or fluent control over, a secondary Discourse" (Gee, 1990:153) and pointed out that as there are multiple Discourses there will be multiple literacies.

This theory underlies the approach of the New Literacy Studies which conceptualises literacy and numeracy as social practice (Street, 2005; Street & Baker, 2006; Kelly, Johnston & Baynham, 2007). McKenna (2009:21) expresses this by stating that we need to understand the academic disciplines as "communities requiring certain literacy practices of their members". In higher education there are different quantitative literacy practices associated with different academic disciplines, so it does not make sense to talk about being quantitatively literate, independently of the Discourse where this literacy is to be practised.

I adopt the following definition of quantitative literacy:

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, graphically, in tabular or symbolic form; it requires the activation of a range of enabling knowledge, behaviours and processes and it can be observed when it is expressed in the form of a communication, in written, oral or visual mode (Frith & Prince, 2006:30).

The development of this definition was most strongly influenced by the definition of numerate behaviour underlying the assessment of numeracy in the Adult Literacy and Lifeskills (ALL) Survey (Gal, van Groenestijn, Manly, Schmitt & Tout, 2005:152) and the view of literacy as social practice. It has significant overlap with what some writers refer to as "Document Literacy" (Mosenthal, 1996:314) as well as with "Statistical Literacy" (Gal, 2005:48). Although not specifically stated in the definition, quantitative literacy often also encompasses a degree of computer literacy, as quantitative information is frequently accessed through this medium. In many situations, using a computer will be a component of the relevant "enabling knowledge, behaviours and processes". Frith and Prince (2009:89) give a detailed summary of our view on what a student needs to be able to do in order to practise quantitative literacy.

Given that quantitative literacy is practised as a component of an academic Discourse, and language is integral to any Discourse, it is clear that quantitative literacy and language cannot be disentangled. Quantitative information and concepts are conveyed through language, often using precise terminology and forms of expression that are associated with specific quantitative ideas. The language used for expressing quantitative concepts often uses everyday words with very specific meanings (consider, for example, the word 'rate' in the phrase 'birth rate' or the word 'relative' in the phrase 'relative proportions'). A student will not encounter this kind of expression in isolation, but will have to interpret or use it embedded in the language of the disciplinary Discourse.

Curriculum for quantitative literacy development

Quantitatively, literate behaviour can be understood in terms of

- the *contexts* that require the quantitative literacy practice;
- the mathematical and statistical concepts and techniques (*content*) that are required by the practice, and

- the underlying *thinking and competencies* that are called upon, for example, the ability to interpret data or quantitative text and ask critical questions about its validity, or to write statements about it.

In this article I am using the term ‘context’ to refer to the disciplinary context in which the students’ quantitative literacy is being exercised. For example, in the experience of a Law student, the ‘context’ might be that of a specific case that is being studied, while the ‘content’ will be the necessary mathematics or statistics that a student must know and do in order to understand the case. The ‘context’ is presented to students through the medium of a text of some kind and thus the information about the context and the quantitative information are embedded in the disciplinary secondary Discourse. Thus, it appears self-evident that the most effective curriculum structure for the development of students’ quantitative literacy (and other literacies such as academic literacy) would therefore integrate it into the disciplinary curriculum, and ideally not make it the responsibility of a separate add-on course. Jacobs (2007:872), in writing about academic literacy in general, explains this by stating that students are inducted into Discourses by modelling themselves on ‘insiders’ and that therefore “discipline-specific academic literacies are best taught by ‘insider’ disciplinary lecturers, who have mastered the Discourses of those particular academic communities”.

Referring to the mathematical and statistical content, some of the most relevant mathematical techniques for Humanities and Law students, when stripped of the complexities of the context, are relatively trivial, but it is the interpreting, reflecting and thinking critically about the diverse situations and verbal and visual messages involving quantitative information that is mentally challenging. It is also obvious that learning techniques in isolation does not assist students to transfer this learning to situations in contexts where these techniques need to be applied. For example, Gal (2009:58), in writing about statistical literacy, states that:

Instructors should not assume that students who have been exposed only to ... decontextualised ... tasks in the classroom ... will be able to interpret, reflect upon, and think critically about diverse ... situations and verbal messages that they may encounter in real life.

However, in our situation, the structure within which we are working for the Humanities and Law students is a separate quantitative literacy course which they experience in their first semester of first year. As a result, the integrating of the quantitative literacy competencies into suitable contexts must be addressed in the design of this course. This is done by designing learning materials that strive to present the necessary mathematical and statistical knowledge and procedures within contexts that we believe closely mimic those of the disciplines. The disciplinary curriculum is already at one remove from the authentic practices of say law or psychology through the process of recontextualisation (Bernstein, 1990:183) into pedagogic Discourse. It is possible to view the process of our curriculum design for quantitative literacy as a further recontextualisation of the disciplinary curriculum, leading to a two-tier process of recontextualisation. The fact that our teaching of quantitative literacy is at two removes from the practices for which students are being educated leads to many of the tensions we experience. There is a fundamental contradiction underlying the quantitative literacy course (which leads to this double level of recontextualisation as a compromise): the curriculum structure that dictates that the development of students’ quantitative literacy be addressed in a separate course early in their programme is premised on the idea that a literacy can be treated as a “generic mode” (Bernstein, 2000:53) in which the voice of the discipline is necessarily weak (Ashwin, 2009:94), while the nature of quantitative literacy itself (as practice embedded in a Discourse) ideally requires strong integration with the disciplinary courses for its development.

There is one respect in which quantitative literacy is different from other literacies, namely the mathematical and statistical knowledge and procedures that are involved in quantitative literacy practice and that need to be taught in a quantitative literacy course. Despite the arguments in favour of embedding the development of quantitative literacy within Discourses, this approach can disadvantage some students as there is evidence that teaching mathematical skills in context can cause students who have less developed language or academic literacy to become confused about what learning is valued, making the learning less effective (Zevenbergen, Sullivan & Mousley, 2002:8; Lerman & Zevenbergen, 2004:40; Ensor & Galant, 2005:291; Venkat, Bowie & Graven, 2009:85). Given that some of our students lack basic mathematical

skills and that many of our students find it difficult to adapt to the language and academic literacy demands of the curriculum, we need to be cautious about allowing their learning of the basic mathematical and statistics techniques to be overwhelmed by the complexities of the contexts.

The quantitative literacy course for Humanities and Law students

Law students and Humanities students intending to study psychology or economics complete essentially the same quantitative literacy course provided by the Numeracy Centre in the first semester, although they are taught separately and register under different course codes. The students who take this course are either registered on an extended (four-year) degree programme, in which case it can be considered a 'Foundation course', or are required to complete the course as a result of their performance on the National Benchmark Test for Quantitative Literacy.

The course has the general objectives, namely that students should be able to:

- read text, tables and graphs containing quantitative information critically and with understanding;
- express quantitative information in clear English, using tables and graphical representations where appropriate, and
- use a spreadsheet application to analyse and represent data.

Since 2009, the first half of the curriculum of this course has been structured around three contexts: a module on children's rights, followed by one on xenophobia and then one on prison overcrowding. In the three context-based modules we present students with edited extracts from research reports of the kind which we believe they will encounter in their disciplinary studies and professions. 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 these modules students engage with substantial real contexts, and the necessary mathematics and statistics that arises is developed as needed. Thus, the underlying organisational principle for the curriculum is the contexts, not the coherent development of mathematical content knowledge. The motivation for this is that it more closely mimics the reality of the quantitative literacy practice in the disciplines, and we assume that this will facilitate transfer of the relevant quantitative competencies.

Table 1 presents a summary of the curriculum for the three context-based modules in the first half of the course. Unlike the intervention itself, this summary is structured around the main mathematical and statistical content so as to expose the topics that we believe are important.

Table 1: Summary of mathematical and statistical content covered by the three context-based modules

A cross indicates that a content topic is addressed in the relevant context module	Context module		
	Children's rights	Xenophobia	Prison overcrowding
Content topic:			
Fractions	X		X
Negative numbers		X	
Ratios	X	X	X
Probability	X		
Percentages: absolute number vs. percentage	X	X	X
Calculating a percentage	X	X	X
Calculating the whole given the percentage	X		
Expressing the size of a change as a percentage	X	X	X
Increasing or decreasing by a given percentage	X	X	
Calculating the value before a percentage change	X		
Change in percentage points	X	X	X
Compound change	X		

Content topic:	Children's rights	Xenophobia	Prison over-crowding
Tables	X	X	X
Bar charts		X	X
Pie charts	X	X	X
Line charts	X	X	X
Scatter plots and line of best fit		X	
Frequency tables and charts	X	X	X
Sampling and bias		X	
Sampling and confidence intervals	X		
Average	X		
Rank, range, quartiles, quintiles, interquartile range	X		
Scientific notation	X		
Significant figures	X		
Variables		X	
Area of a square and a rectangle			X

The second half of the course, which deals with financial mathematics and descriptive statistics, retains the structure which we used previously for the entire course, where the modules are built around the different categories of mathematical and statistical content, although the material is always presented in authentic or realistic contexts. The computer-based learning tutorials are intended mainly to support the learning of data-analysis and representation as well as to teach students how to use a spreadsheet application (Microsoft Excel, in this instance) for this purpose.

Some limitations on the effectiveness of the course

In order to gain insight into the first implementation of the curriculum for the quantitative literacy course described earlier, in particular the context-based first part, the following kinds of data were collected. All the weekly staff meetings, at which the progress of the course was discussed, were recorded and a selection of classroom sessions was observed in two different classes. At the end of the course, focus group interviews were conducted with three groups of students. The discussion that follows deals with some of the themes arising from these observations, in particular those relating to difficulties experienced as a result of the tensions that arose between the contexts and the mathematical and statistical content in teaching and learning.

In designing a stand-alone quantitative literacy course for specific disciplines, the major challenge has to do with the recontextualisation of the disciplinary curriculum by identifying and selecting suitable contexts that will mimic the disciplinary Discourse which these students will encounter in other courses. Given our experience that the students entering higher education have significant difficulties with the required mathematical and statistical knowledge and techniques, the contexts we choose must not demand a great deal of specialised knowledge, as we cannot afford to spend much of our limited course time on teaching students about the features of specific contexts or on developing the necessary language competencies.

In the teaching of the course we encountered two major difficulties in this respect. First, even though we judged that the contexts we used (children's rights, xenophobia and prison overcrowding) were reasonably accessible, our experience in the classroom revealed that we had unrealistic expectations for students' familiarity with the contexts and with the meanings of commonly used English words associated with them. For example, some students defined the word 'nationwide' used in one text as meaning 'all over the world' and many made no distinction in meaning between the words 'migration' and 'immigration'. From experience we anticipate that students will have difficulties with the language used

to express quantitative concepts, but we misjudged their level of familiarity with the language used in the disciplinary discourse.

Secondly, many students apparently lacked interest in the contexts and engaged superficially with them. This is understandable due to a lack of authentic motivation to engage with the contexts, as insight and understanding of the contexts is not perceived to be the main focus of the course and contributes only a small part of the assessment. This could be construed as a consequence of the two-tier recontextualisation inherent in the design of the course, leading to a separation between the disciplinary Discourse and the material in the quantitative literacy course and a consequent perception of irrelevance by the students. The result of these difficulties was that we had to spend more time than anticipated on engaging with the contexts in class, which reduced the time we could spend on the mathematics and statistics concepts.

Not only were the contexts eclipsing the content in terms of time devoted in class, but the way that different mathematical concepts arose in the course (being in the service of understanding the contexts) meant that some of the students did not build up a coherent understanding of the underlying structures of the mathematics content. We sensed that the learning of the mathematics was disjointed. 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: ... this is percentage increase, or percentage change, these are percentage points' (Audio recording of staff meeting, 2009).

In this instance, the lecturer is expressing her sense that students need to be given a 'road map' of the skills and concepts making up the mathematical and statistical content of the course.

Students are used to a school mathematics curriculum that stresses abstract procedures not presented in context. Therefore, when they were exposed to our more integrated context-based course material in what they thought was a mathematics course (since it carries a mathematics course code), some of them found it difficult to recognise what was valued by us in terms of their learning. It appears that the way we conducted our classes and the nature of the learning material did not convey this clearly enough to some of the students. This is illustrated, for example, in the following quote from a focus group interview:

I always find that with maths I always do the opposite of how I do in my other courses and ... I mean there you go on writing the summary and then you get half a mark and then I'll be like, 'I don't understand, half a mark, how do I get half a mark?' and then you know, it's always like hard to really understand where you went wrong (Audio recording of focus group interview, 2009).

This student is highlighting her lack of clarity on what kinds of answers were appropriate in assessments, and her choice of example ("writing the summary") points to difficulties with using quantitative language appropriately in context.

Since we had to spend time in class explicating the context material, some students found it difficult to anticipate that what we valued was their ability to apply the mathematical knowledge in context, not their knowledge of the context itself. We deduced this from the kinds of questions they asked about how to prepare for assessments. We also found that some students did not understand the nature of the engagement with the context that we valued. We wanted them to display a rigorous academic engagement (for instance, only making statements that are supported by evidence available in the data), but our classroom practice did not make this clear. This was because in the process of helping students to understand the context, in the classroom we did encourage them to draw on their experience and own opinions, but then in assessments we did not value this kind of knowledge.

Conclusion and recommendations

It is clear from the results of testing first-year students on entry that there is an articulation gap between the quantitative competencies of many first-year Humanities and Law students and the likely quantitative demands of their courses. The quantitative literacy course for Humanities and Law students described in this article attempts to address this gap.

The framing of quantitative literacy as social practice embedded in disciplinary Discourses dictates that interventions intended to develop students in this area should attempt to achieve the maximum degree of integration of the quantitative concepts into the disciplinary Discourse. In our case, where we are providing a separate course, we attempted to approach this kind of integration by changing from a content-based to a context-based curriculum at least in part of our quantitative literacy course. I believe that by doing this we achieved our purposes and served our students' needs more appropriately, but the context-based nature of the learning materials led to tensions experienced by both lecturers and students. Although it has not changed our belief that a context-based curriculum is appropriate for these students, the experience of implementation of this kind of curriculum raised questions about some of the assumptions we made about the appropriate balance between context and content and about the efficiency of such a curriculum in promoting transfer.

I regard these questions as indicating ways in which we should further develop the curriculum as well as areas for research. Although in a complex environment such as the quantitative literacy course (and the programme of study of which it is a part) there are no easy solutions to students' and lecturers' difficulties, and there are some changes we can make to address some of the tensions I have identified (some of which have already been implemented):

- We should be more explicit in clarifying the distinctions between the disciplinary context and the mathematical and statistical content.
- We should introduce 'summary lectures' and focused tutorials to assist students to develop a coherent sense of the mathematical and statistical content structure.
- We should concentrate more on explicitly developing students' ability to use and comprehend quantitative language in the context of the disciplinary Discourse.
- We should make more explicit what counts as valid knowledge and valid performance in assessments.
- We should recommend and encourage students to engage with resources that would motivate their interest in and increase their understanding of the contexts.

Implementing these suggestions is a first step in the ongoing evaluation and further re-development of our first-year quantitative literacy course, with the ultimate goal of achieving the optimum degree of integration and student motivation.

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