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# Quantitative literacy provision in the first year of medical studies

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## Abstract

This article presents a description of and motivation for the quantitative literacy (numeracy) intervention in the first year of medical studies at a South African university. This intervention is a response to the articulation gap between the quantitative literacy of many first-year medical students and the demands of their curriculum. Interventions of this kind should be integrated into the medical curriculum, primarily because quantitative literacy is a practice which is embedded in the disciplinary practices. Tensions involved in attempting this integration are largely due to structural conditions and other curricular factors. Results of evaluation of its effectiveness show that the intervention is seen as useful by the students and that the workshops provided are effective in improving students' performance in assessments. The intervention should be enhanced by including aspects that address students' spatial abilities and reading and writing competencies. Extension of quantitative literacy provision beyond first year is also desirable.

## INTRODUCTION

In South Africa, where students begin their study of medicine (MBChB) straight after leaving school, there is a need for curriculum interventions to reduce the 'articulation gap' (Scott, Yeld and Henry 2007, 273) which exists in many cases between the demands of curriculum and the students' quantitative (and other) literacies. This is particularly important for improving access to and promoting success in tertiary study for students with disadvantaged educational backgrounds (Frith and Prince 2006). The importance of quantitative literacy (also known as numeracy) in higher education curricula has also been increasingly recognised internationally (Chapman 1998; Steen 2004). Quantitative disciplines such as health sciences make complex demands in terms of quantitative literacy, for which traditional mathematics courses do not prepare most students adequately (Hughes-Hallet 2003).

In this article I will describe a quantitative literacy intervention carried out collaboratively between academic development lecturers and the lecturers of the first-year integrated medical courses (referred to as Lifecycle and Transitions in Health) which form the core of the first-year medical curriculum at a South African university. This article is not a report of a research study, but describes approaches to and discusses factors influencing the effectiveness of implementing a quantitative literacy intervention in a higher education discipline. This is offered as a stimulus

to further debate about this important area of development, which is relevant to educators in many disciplines, not only in health sciences. I will begin with a discussion of the need for the intervention then describe how it is implemented and some of the tensions that arise in the implementation. I will conclude with some examples of empirical observations on its effectiveness and some recommendations for further developments.

## **PERSPECTIVES ON QUANTITATIVE LITERACY**

Quantitative Literacy is a 'slippery concept, the subject of lively debate' (Coben et al. 2003, 9) particularly in Australia and England (where it is usually called 'numeracy') and in the United States (where it is most often called 'quantitative literacy'). This debate concerns itself not only with the definition of the concept, but also with its relationship to mathematics itself. Hughes-Hallett (2001, 94) expresses the distinction between quantitative literacy and mathematics as follows: 'Mathematics focuses on climbing the ladder of abstraction while quantitative literacy clings to context. ... Mathematics is about general principles that can be applied in a range of contexts; quantitative literacy is about seeing every context through a quantitative lens.'

This idea that quantitative literacy is mainly concerned with mathematics and statistics used in context is fundamental to all its definitions, whether it is seen as social practice (Street 2005; Street and Baker 2006), a critical approach (Johnston 2007) or a component of a more general idea of literacy (Chapman and Lee 1990). At the very least then, the definitions garnered from this debate would agree that numeracy is to do with "using maths in context" and that to be numerate is to have the "capacity to use maths effectively in context" (Johnston 2002, 4). Some authors even claim that numeracy is "not less than or even part of mathematics, but something more than mathematics" (Johnston and Yasukawa 2001, 280), being "the ability to situate, interpret, critique, use and perhaps even create mathematics in context ..." (Johnston and Yasukawa 2001, 279).

In the Further Education and Training curriculum in South Africa the definition of 'Mathematical Literacy' is as "a subject driven by life-related applications of mathematics" (Department of Education 2003, 9). If we think about quantitative literacy in Higher Education from this perspective we focus on those 'life-related' applications that occur within the 'life' of academic disciplines.

The debate about the definition brings to the fore the framing of quantitative literacy as a social practice, with a focus on defining what a mathematically literate person does, rather than what collection of topics, skills and contexts quantitative literacy could be thought to consist of. This view of quantitative literacy as social practice in the tradition of the New Literacies Studies has been developed by Street and Baker (Baker 1998; Street 2005; Street and Baker 2006), Kelly Johnston and Baynham (2007) and Prince and Archer (2008). Johnston (2007) and Yasukawa (2007) also conceptualise numeracy as social practice, but focus on the individual's critical awareness, defining numeracy as 'a critical awareness that builds bridges

between mathematics and the real world' (Johnston 2007, 54). This definition is derived from their work with basic adult education as well as with students in tertiary education.

The view of quantitative literacy as social practice informs our view of its role in higher education and leads to our adoption of 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, 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 and Prince 2006, 30).

This definition emphasises that communication of quantitative ideas using different modes is an essential component of quantitatively literate practice. This is an area where the boundaries between quantitative literacy and other academic literacies (such as writing and computer literacy) overlap and interesting opportunities for interdisciplinary curriculum development can arise.

In studying medicine, students are expected to become competent quantitatively literate practitioners within this discipline. Thus quantitative literacy can be seen as a set of practices embedded in the contexts of the various sub-disciplines in which medical students are apprenticed (Lave 1997). The quantitative literacy intervention described in this article is intended to support students in developing these practices.

## **MOTIVATION FOR QUANTITATIVE LITERACY TO BE ADDRESSED IN THE CURRICULUM**

Systematic examination of the curriculum for the integrated course Transitions in Health revealed that the quantitative literacy demands are extensive and very varied. The curriculum assumes a well-developed ability to interpret graphical representations of processes and of data. Human biology (anatomy, physiology and histology) make extensive use of a student's spatial ability to interpret diagrams and micrographs and to visualize structures in three dimensions. A clear understanding and familiarity with the concepts of scale and magnification is essential in these disciplines. Medical biochemistry and physiology in particular require the ability to interpret a variety of different complex visual representations.

The degree of algebraic or computational ability required by the Transitions in Health course is moderate, but the courses in chemistry and physics naturally draw heavily on these competences. Proportional reasoning is fundamental to understanding in many situations, especially in the discipline of public health. This discipline also requires reasoning about probabilities and the ability to interpret and critique data representations and statistical analysis.

Although all medical students have studied mathematics at school, it cannot be assumed that this will have prepared them to meet the quantitative literacy demands of the curriculum. Quantitative literacy is not the same as mathematics, the main distinctions being that quantitative literacy is a practice which is always embedded in a specific context and that data analysis and interpretation play a prominent role in this literacy (Hughes-Hallet 2001; Kelly Johnston and Baynham 2007). Students' school mathematics experience will not have exposed them to applying the mathematical techniques in real contexts and the statistical content of the school mathematics curriculum is minimal. It can also not be assumed that all students will have developed other competencies required by the curriculum (identified above) such as interpretation of complex spatial representations, a feeling for scale and reasoning with proportions.

Since the year 2000, we have tested all first-year entry-level students in our Health Sciences Faculty with an instrument designed to assess the basic quantitative literacy competency of university students. The results of this testing have shown that many students lack quantitative concepts and techniques that medical courses appear to assume students will have.

By way of illustration the results for a selection of some of the simplest questions are presented in Table 1. The first two questions listed were short problems presented verbally as a description of a real circumstance, where the numbers used were small and the answers were whole numbers. Question A required students to divide a two-digit number in a simple given ratio. Question B required students to calculate a simple fraction of a total, and then find a different simple fraction of the rest. The other two questions were stated more directly. Question C simply asked students to identify the number (given with four decimal places) that was closest to a given single-digit number and Question D required them to find the median of a small number of single-digit numbers that were not given in order.

Table 1: Examples of MBChB students' performance on quantitative literacy test questions

Year of testing:		2002	2003	2004	2005	2006	2007	2008
Question:		% of students who answered question correctly						
A	Divide in given ratio	68	70	70	69	74	71	78
B	Fraction of fraction	89	89	87	90	82	70	88
C	Find closest number	67	74	75	74	85	83	88
D	Find median	52	49	45	45	58	44	51

The results in the Table 1 illustrate how between 22 per cent and 32 per cent of the students entering MBChB cannot divide a number in a given ratio (A) and over 10 per cent cannot calculate a fraction of a fraction of a number (B) in short problems presented verbally. Between 12 per cent and 33 per cent could not identify

the number closest to a given whole number (C) and about half of the students could not find the median of a small collection of single-digit numbers (D).

I present these observations to support the claim that quantitative literacy needs to be addressed explicitly in the first-year MBChB curriculum, bearing in mind that the quantitative demands of the curriculum are generally much more complex and subtle than what is called for by these decontextualised questions from the test.

## **INTEGRATION OF QUANTITATIVE LITERACY PROVISION**

Quantitatively literate behaviour can be understood in terms of:

- the contexts that require the quantitative literacy practice: for example, health indicators (such as birth and mortality rates) used in public health documents;
- the mathematical and statistical concepts and techniques (content) that are required: for example, the concept of ratio and the mechanics of calculating ratios (rates, fractions, percentages);
- the underlying thinking and behaviours that are called upon to respond to a situation: for example, the ability to interpret public health data and ask critical questions about its validity, or to use data in presenting a written argument.

When engaging with quantitative information in context a student has to keep the understanding of the disciplinary context and of the mathematical or statistical content in constant interplay, as well as bring to bear the necessary thinking and critical capacities.

A quantitatively literate person must be able to think mathematically in context. This requires a dual duty, marrying the mathematical meaning of symbols and operations to their contextual meaning, and thinking simultaneously about both (Steen 2004, 25).

Since the disciplinary context is so intimately married to the mathematical and statistical content in the practice of quantitative literacy, it appears self-evident that the most effective curriculum structure for the development of students' quantitative literacy will involve integration of the quantitative content into the disciplinary context. This is also consistent with the theory of situated cognition, which claims that we cannot 'assume that conceptual knowledge can be abstracted from the situations in which it is learned and used. ... knowledge is situated, being in part a product of the activity, context, and culture in which it is developed and used' (Brown, Collins and Duguid 1989).

It is also true that some of the most relevant mathematical techniques, when stripped of the complexities of the context, are relatively trivial, but it is the application of the quantitative knowledge in context that is mentally challenging (Steen 2004). However, there is also evidence that teaching mathematical skills in context can confuse particularly those students who have less developed language

or academic literacy, and so make the learning less effective (Frith et al. 2010; Ensor and Galant 2005; Zevenbergen, Sullivan and Mousley 2002). Given that some of the MBChB students lack the most basic mathematical skills (as shown in Table 1) and it is very likely that these same students are educationally disadvantaged in other ways, for example in terms of language, we need to be cautious about allowing the learning of the basic mathematical and statistical techniques to be overwhelmed by the complexities of the contexts. On the other hand, we could not reasonably expect the majority of students in a medical course to engage seriously with mathematics and statistics concepts without the motivation of the relevance of the medical context.

Integrating the quantitative literacy provision into the medical courses to the maximum extent also maintains an alignment with the principles underlying the design of the entire medical curriculum. The core courses in this curriculum employ a supported problem-based learning approach (Van Pletzen 2006) and strive to integrate the knowledge of the various different traditional medical disciplines as well as the other competencies that students need to develop. Thus it is logical that an intervention intended to support students in developing the necessary quantitative literacy practices should be presented as part of this curriculum structure.

### **THE QUANTITATIVE LITERACY PROVISION FOR FIRST-YEAR MBCHB**

The quantitative literacy intervention provided through a collaboration of academic development staff and the course lecturers has the core objectives that students should be able to:

- Read text, tables, charts and graphs containing quantitative information critically and with understanding.
- Express quantitative information in clear English, using graphical representations where appropriate.
- Use a spreadsheet application to analyse and represent data.

I have argued that it is desirable to aim to integrate the quantitative literacy provision into the students' experience of the contexts studied in the medical curriculum. Ideally this could be done by ensuring that the lecturers of the medical courses were fully aware of the quantitative demands made by their curricula and the likely difficulties that students would experience with them, as well as knowing how to address these difficulties within their courses. For university lecturers whose quantitative literacy practice is fluent in their discipline, it is difficult to recognise explicitly the quantitative demands placed on students who are novices in the discipline (Frith and Prince 2009). In addition they are not necessarily able to see how best to teach the quantitative content even if they realise that they should do so. For this reason it is necessary to involve academic development practitioners who are quantitative literacy specialists in the curriculum design and implementation.

The ideal would be for the academic development lecturers to work alongside the disciplinary lecturers to enable them to respond to the quantitative literacy needs of the students within their courses, but for various reasons (historical, political, structural and practical) this is often not possible. These considerations have led to the quantitative literacy provision for the students in our case being provided by academic development staff. For practical reasons it is necessary to schedule specific classes for dealing with the quantitative literacy content and to assess it in a partially integrated way, and the ideal degree of integration is not achieved.

So the integration of the quantitative literacy provision into the medical courses is addressed in the design of the relatively isolated quantitative literacy learning experiences and assessment provided by the academic development staff. This is done by designing learning materials that develop students' quantitative practices within the medical contexts that are being studied concurrently in the medical courses. Thus the quantitative literacy provision is a component of the 'support' provided for each of the cases studied in the 'supported problem-based learning' curriculum.

In practice the quantitative literacy provision consists mainly of learning materials (worksheets that are a combination of resource materials, explanatory notes and exercises) for all first-year medical students; supported by compulsory weekly workshops led by an academic development lecturer for students identified by testing as needing assistance with completing the worksheets. In line with the conception of quantitative literacy as social practice, the exercises in these worksheets make quite heavy demands on students' ability to comprehend and write academic language used to express quantitative concepts.

The integrated Lifecycle course which is the core of the first semester medical curriculum deals with normal human development throughout the lifespan. At the same time the students complete physics and chemistry courses. The quantitative literacy although tied to the structure of the Lifecycle course and assessed in the tests for this course, also includes some material designed to support the learning in chemistry and physics. In a similar manner the quantitative literacy for the second semester is associated with the integrated Transitions in Health course. Most of the quantitative literacy material in the second-semester intervention, which includes a substantial series of spreadsheet-based computer learning materials, is closely integrated with the public health component of this course.

Tables 2 and 3 present a summary of the quantitative literacy curriculum in the first and second semesters respectively. Unlike the intervention itself, this summary is structured around the main mathematical and statistical content so as to expose the concepts we have identified as most necessary to enable a first year medical student to understand the medical content in the first year and to prepare for subsequent years. The last column lists examples of some of the higher order thinking and behaviour that we try to develop in our intervention.



Table 2: Summary of quantitative literacy curriculum for the first semester of MBChB

Mathematical and statistical content	Some contexts used	Examples of thinking/behaviour required
Ratios, direct proportion, percentages Understand and work with ratios, (including direct proportion and percentages) in context	Birth rates	Appreciate the distinction between relative proportions and absolute quantities
Percentage change Understand and work with percentage change	Birth rates Cost of medicine	Appreciate the distinction between relative change and absolute change
Indirect proportion Understand and work with indirect proportions in the context of dilution	Solutions	Understand inverse relationships
Significant figures and precision in measurement Understand the concept of significant figures in computations using measurements, and the conventions used for representing and determining them	BMI, measurements	Develop a feel for the connection between variability and error in measurements
Logarithms and logarithmic scales Understand the use of logarithmic scales of measurement in situations where there is a very large range of values	Hearing, pH	Think in terms of orders of magnitude
Exponential change Do calculations in the context of exponential growth (and decrease)	Population growth, investment	Understand the idea of changes in rates of change Transfer ideas to unfamiliar contexts
Representing frequency distributions Create a frequency table from raw data Calculate percentage frequencies and cumulative percentage frequencies Represent frequencies and cumulative frequencies graphically in histograms and cumulative curves Draw and interpret a box-and-whisker chart	Body weights and heights, BMI	Analyse a data set to choose appropriate intervals for grouping of data Reason with inequalities Translate between different representations
Descriptive statistics Understand and work with percentiles (including median, quartiles) of a distribution Read off values for the percentiles of a distribution from a cumulative curve Understand, calculate and work with the statistical measures for central tendency (mean and median) and for spread (range, interquartile range) Compare distributions of data in terms of central tendency and spread	Body weights and heights, BMI Risk-taking behaviour	Make conceptual links between different representations of same concepts Generalise ideas from specific cases Reason about distributions, data and uncertainty
Error in measurement Understand and work with the standard deviation Use the standard deviation of repeated measurements to estimate the number of significant figures in the mean	BMI, various measurements	Reason about distributions, data and uncertainty

Mathematical and statistical content	Some contexts used	Examples of thinking/behaviour required
<p>Graphs of functions</p> <p>Draw and interpret graphs showing how the percentiles of a distribution will change with age for a particular population (growth charts)</p> <p>Translate between different representations of a relationship: verbal, tabular and graphical</p> <p>Recognise that rate of change is indicated by steepness of a graph at a point</p> <p>Understand the distinction between (and relationship between) graphs of a variable and graphs showing the rate of change of a variable</p>	<p>Body weights and heights, BMI: growth charts</p> <p>Enzymes and reaction rates</p> <p>Oxygen saturation curves</p> <p>Growth of a culture</p>	<p>Make connections between data distributions and changes over time</p> <p>Interpret shapes of graphs in terms of differences in rates of change</p> <p>Make connections between quantities and rates of change of quantities</p>

Table 3: Summary of quantitative literacy curriculum for the second semester of MBChB

Mathematical and statistical content	Some contexts used	Examples of thinking/behaviour required
<p>Ratios, direct proportion, percentages</p> <p>Understand and work with ratios and rates in context</p>	<p>Epidemiology, incidence and prevalence of disease, HIV, burns, diarrhoea, TB</p> <p>Infant mortality rates, risk-taking behaviour</p>	<p>Apply the definitions of measures of extent of disease in context</p>
<p>Percentage change</p> <p>Understand and work with percentage change.</p>	<p>TB data</p>	<p>Appreciate the distinction between relative change and absolute change</p>
<p>Data represented in text, tables and charts (bar charts, stacked bar charts, line charts)</p> <p>Read text, tables and graphs containing quantitative information</p> <p>Express quantitative information graphically, in tables and in clear English, for example describe trends</p> <p>Make predictions from trends in data</p>	<p>Infant mortality rates, Incidence and prevalence of disease: HIV, burns, diarrhoea, TB</p> <p>Risk-taking behaviour</p>	<p>Analyse information about data critically and with understanding</p> <p>Integrate knowledge of ratios with knowledge of data representations.</p> <p>Make comparisons and recognise trends</p>
<p>Probability, measures of association</p> <p>Use proportions in data as estimates of probability</p> <p>Calculate risk ratio and odds ratio from data in contingency tables</p> <p>Interpret the values of risk and odds ratios</p>	<p>Hypertension heart disease</p>	<p>Communicate the meaning of the value of a measure of association as a result of a study</p>

Mathematical and statistical content	Some contexts used	Examples of thinking/behaviour required
<b>Sampling</b> Recognise the structure of different types of study design: cross-sectional, case-control, cohort and experimental	Hypertension heart disease Risk-taking behaviour	Appreciate the effects of sampling on the reliability of results Analyse a description of a study
<b>Confidence intervals</b> Understand the relationship between a confidence interval of a sample statistic and the corresponding population parameter e.g. means, proportions Interpret the values of risk and odds ratios with given confidence intervals	Risk-taking behaviour	Understand the difference between a population distribution and a sampling distribution Communicate the meaning of a confidence interval
<b>Hypothesis testing and p-values</b> Interpret the value of a p-value in the context of reported results of studies	Interpersonal violence and risk-taking behaviour	Appreciate the concepts of statistical significance and error in measurements
<b>Correlation and concept of best-fit line</b> Draw a scatter plot for paired data Interpret the degree of scatter of points in terms of a rough description of degree of association Interpret value of correlation coefficient in terms of a rough description of degree of association	Exercise and fitness Infant mortality rates, diarrhoea	Appreciate the difference between correlation and causation

## EFFECTIVENESS OF THE QUANTITATIVE LITERACY PROVISION IN FIRST-YEAR MBChB

Given that our objective is to assist students to develop appropriate quantitative literacy practices within their medical disciplines, our intervention would be considered successful if students successfully transfer what they learn from the quantitative literacy materials and workshops to their other courses in first year and to courses in later years. Unfortunately it is not possible to evaluate whether this kind of transfer is taking place, not least because we do not know how they would have behaved in the absence of the intervention. The effects of the intervention are not easily measurable and access to relevant data is difficult to obtain. However it is possible to evaluate students' perceptions of the relevance and usefulness of the intervention and to examine the effectiveness of the workshops which are part of the intervention by comparing the performance (in assessment questions) of those who attended the workshops to the performance of those who did not.

The Lifecycle and Transitions in Health courses are continually evaluated by canvassing a sample of the class at the completion of each unit of study. These surveys include questions about the students' experiences of the quantitative literacy intervention. We also request the students who attend the quantitative literacy workshops to complete a fairly comprehensive course evaluation questionnaire at

the end of each semester and we include an evaluation questionnaire in one of the computer-based tutorials. A comprehensive report of the results of these evaluations would not be appropriate here, but some observations are relevant to a discussion of the effectiveness of the intervention. The intervention has been provided in the form described here since 2004 and similar results are obtained each year. In this discussion I will use data from the year 2008, when the intervention was well-established in its current form.

Two main points emerged from the evaluation of the quantitative literacy intervention in the ongoing evaluation of the Lifecycle course. The opinion of students generally was that the intervention was useful in assisting them with skills development and the understanding of quantitative concepts. However there were differences between the views of those who attended compulsory workshops, and those who completed the quantitative literacy exercises independently. Those who attended the workshops in general were positive about the intervention and saw their facilitator's role as crucial in promoting understanding, while those who did not attend the workshops and completed the exercises on their own were more inclined not to value the quantitative literacy materials or see their relevance. This result should not be surprising given that we view quantitative literacy as social practice.

The results of the evaluation of the opinions of those students who were obliged to attend the workshops revealed that students' responses to the course and the course materials was generally positive. For example at the end of the first semester, more than 90 per cent of the students indicated that they had benefited from the workshops and 95 per cent indicated that they would recommend them to other students. However the answers to open-ended questions showed that many students valued the workshops as an opportunity to prepare efficiently for assessments rather more than for providing conceptual understanding that supported their learning in the medical disciplines: 'It was useful going over the exercises which I most likely would not have done had I not been to these classes', 'You get to do QL at least once every week, and thus you don't forget about it unlike other students ... and leave it to the night before'. This focus on preparation for assessments is probably pragmatic on the part of the students, but raises a concern about whether our intervention is successful in developing students' quantitative practices in the context of the medical disciplines in a manner consistent with our conception of quantitative literacy outlined at the beginning of this article.

The comparison of the results at the end of the year for the students who attended workshops (workshop students) and those who did not (non-workshop students) provides evidence that the workshops are indeed effective in terms of improving students' performance on the assessment questions. Two examples, for the years 2008 and 2009, are shown in Figure 1. These charts show the distributions of the change between the aggregate marks for the quantitative literacy assessment questions in the first and the second semesters for the two groups, those who attended workshops in the second semester (mean change +1% in 2008 and -10% in 2009) and those who did not (mean change -9% in 2008 and -21% in 2009). It is clear that there

is a tendency for the non-workshop students to suffer a reduction in performance to a greater extent than the workshop students. In fact in both these examples the difference between the means of the two distributions (for workshop and non-workshop students respectively) is statistically significant at the level above 99 per cent (using a t-test for difference between means).

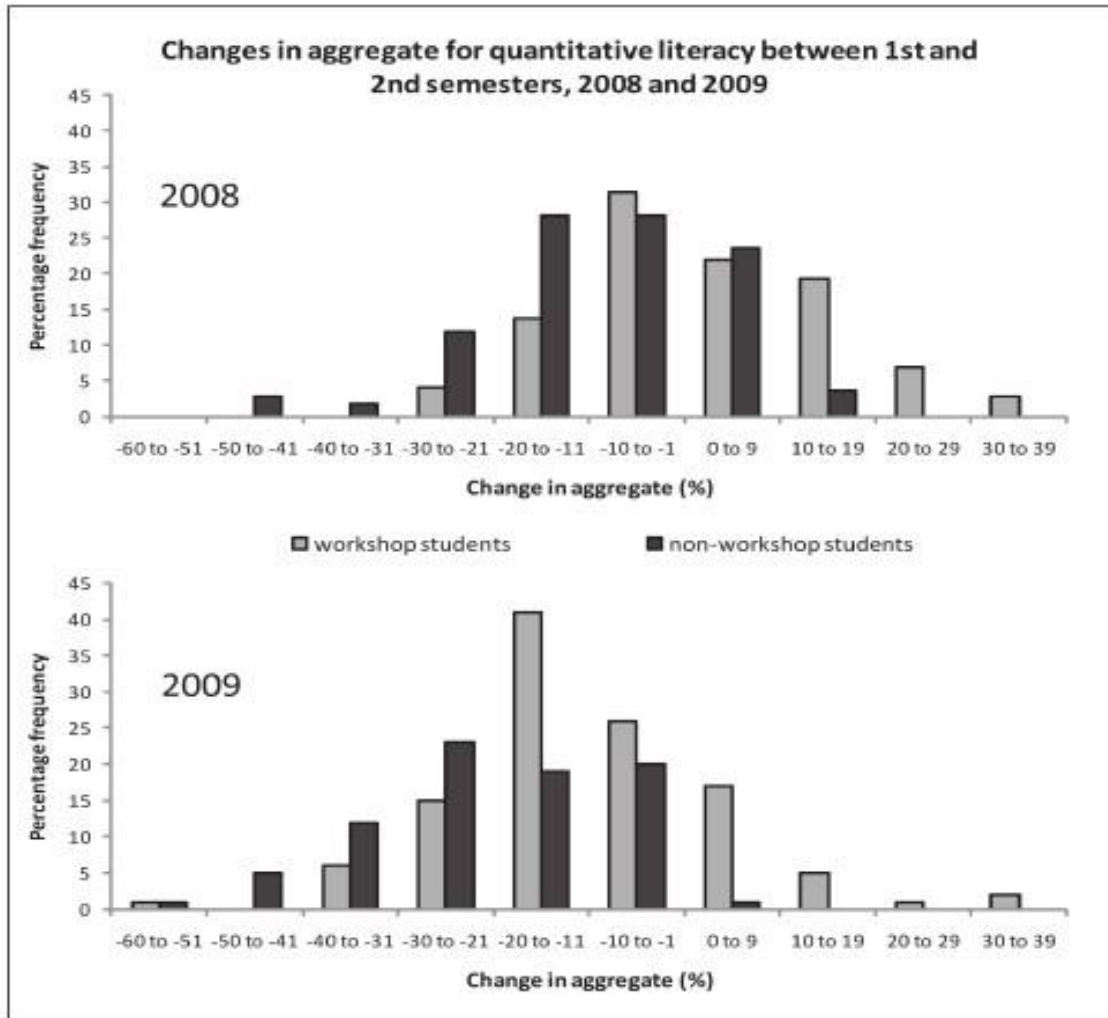


Figure 1: Distributions of changes in aggregate marks between first and second semesters for quantitative literacy assessment questions in 2008 and 2009

These results suggest that it might be desirable for all students to attend the quantitative literacy workshops. This would however require even more resources and a special approach to dealing with the needs of the more able students (currently 'non-workshop' students). In the workshops there are already tensions due to the wide range of abilities displayed by the students who are selected, with the most

able often being resentful and uncooperative. If all students were required to attend workshops one solution would be to employ some kind of streaming.

## **DISCUSSION**

It is clear from the results of testing first-year MBChB students on entry and from our experience of teaching them, that the majority of first-year medical students do not have the quantitative competencies required by their medical courses and that an intervention is necessary. We view quantitative literacy as academic practices in the different medical disciplines and so we believe that a quantitative literacy intervention that attempts to achieve the maximum degree of integration with the medical curriculum is desirable. Ideally this would take the form of the quantitative concepts and practices being taught as an integral part of the medical curriculum.

Practical constraints, however, in our case at present dictate that the quantitative literacy intervention is spatially and temporally separate from the students' other learning experiences. We approach integration of the concepts by embedding the quantitative literacy materials in the medical contexts of the concurrent medical curriculum. Tensions that arise in doing this result mostly from the competing demands of the coherence of the quantitative concepts and the medical contexts, whose order in the curriculum is chosen for reasons unrelated to the quantitative literacy considerations.

The time available for the quantitative literacy workshops is limited and some quantitative competencies identified in the survey of the curriculum of the Transitions in Health course are not addressed in our intervention, in particular the development of students' spatial ability and the ability to interpret a variety of different complex visual representations. A practical approach may be best for developing these abilities and this is an area where a closer integration into the practical medical learning experiences could be attempted.

We regard the communication of quantitative ideas as an important component in our conception of quantitative literacy. As a result we believe we should pay more attention to the development of students' appropriate use of language in academic writing. This opens up an area where further integration and collaborative teaching and curriculum development would be desirable. There is considerable overlap between development of quantitative literacy and language development, for example in developing the appropriate and fluent use of the specialised language used to express quantitative concepts. Co-operative curriculum development involving the academic development staff specialising in language development should improve our ability to assist students in developing the reading and writing competencies called for by their curriculum.

Attempts to integrate the quantitative literacy provision more effectively into the medical curriculum could also address the difficulty we have with those students who do not appreciate the relevance of the quantitative literacy material and who do not engage seriously with it. This problem is exacerbated by the fact that some of

the competencies we attempt to develop are not really called upon by the first-year curriculum, but are necessary as a foundation for later years. Although at the moment we are engaged in laying a foundation of quantitative literacy in the first year of MBChB study, the ideal would be to exploit opportunities to integrate quantitative literacy provision into the subsequent years of study at the most appropriate stages in the curriculum. This would enable the optimum degree of integration and improve the alignment between our conceptualisation of quantitative literacy and our educational practice.

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