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Investigating Alignment in a Quantitative Literacy Course for Social Sciences Students

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Investigating Alignment in a Quantitative Literacy Course for Social Sciences Students

Abstract

The Numeracy Centre at the University of Cape Town has taught a one-semester quantitative literacy course for social sciences students since 1999. This study aims to provide an example for how the design of such a course can be assessed for alignment with quantitative reasoning goals. We propose a framework of learning outcomes for the course and use that framework to analyse the assessments and student performance on them. We find that just under half of the overall mark for the course was devoted to the interpretation and communication of quantitative information (our "main" outcomes), and about a quarter was devoted to the performing of calculations. The analysis revealed that statistics outcomes were under-represented in the make-up of the overall course mark, and assessment of these outcomes was restricted almost entirely to the two final examinations. The results of the analysis of the alignment between outcomes and assessment are useful to inform discussions about changes to the course curriculum. The analysis of student performance on the different outcomes provides insights which are useful for informing improvements to our teaching approach. The analysis demonstrates a relatively straightforward procedure that can be used or adapted by researchers in other institutions for ongoing monitoring of alignment between course outcomes, teaching, and assessment.

Keywords

quantitative literacy, numeracy, alignment, assessment, outcomes

Cover Page Footnote

Both authors have recently retired from the Numeracy Centre, a unit within the Centre for Higher Education Development at the University of Cape Town.

Vera Frith was a founding member of the Numeracy Centre and worked there for twenty-two years. In this role her primary interests were the quantitative literacy development of university students and the appropriate curriculum for this purpose.

Pam Lloyd spent eighteen years as a quantitative literacy lecturer with interests in researching her own practice in order to improve teaching and learning.

Introduction

Many South African higher education students are not adequately prepared by the school system for the requirements of higher education (HE) study. The resulting “articulation gap” is “manifested in students as a lack of sound foundations for tertiary studies, and has a profound effect on students’ ability to respond positively to higher education programmes” (Scott et al. 2007, 42).

One significant effect of this articulation gap is the mismatch between students’ numeracy practices and the expectations of HE in this area. The academic numeracy of most prospective university students is not what the HE sector regards as “proficient” (Prince and Frith 2017). As a result of this gap, most HE institutions provide interventions such as extended programmes and foundation courses for vulnerable students.[1] At the University of Cape Town, the Numeracy Centre provides several such foundation courses as part of its mission to assist the university in ensuring that students have the appropriate quantitative literacy for their disciplines. We focus on one of these courses in this study.

A first semester quantitative literacy course for social sciences students has been taught by the Numeracy Centre since 1999. Over the years the course has evolved from being content-led to context-driven (Frith et al. 2010), and we have developed an understanding of what such a course should and can achieve, but we have not explicitly described our goals in the form of stated learning outcomes. In this we have experienced the challenges identified by Bae et al. (2019) when teaching a context-driven quantitative literacy course—those of defining and operationalising learning objectives. We also believe we have advanced a great deal in our ability to design appropriate assessments for our courses, but we have not formally investigated how well these align with our course goals or with student learning outcomes. In this paper we aim to address these issues by investigating the following research questions (using our course in 2019 as an example):

- What are the learning outcomes of the quantitative literacy course?
- How are the learning outcomes distributed across assessments? (i.e., To what extent are the 2019 assessment questions aligned with the learning outcomes?)
- To what extent did students achieve the learning outcomes in 2019?

We propose a framework of learning outcomes for the course and use the framework to analyse the assessments and student performance on them. In this way we provide quantitative evidence for the degree to which the course assessment is aligned (Biggs 1996) with the stated outcomes. This process is useful to inform

1 Students admitted to degree programmes with less than the usual entrance requirements are placed in four-year programmes that include foundation courses. The usual programme is three years in length.

discussions about changes to the course curriculum. The analysis of student results provides insights into those learning outcomes for which students appear to be under-performing and for which we need to reconsider our teaching approach. The analysis also demonstrates a relatively straightforward procedure that can be used for ongoing monitoring of course alignment between outcomes, teaching, and assessment, including student performance.

In this paper we will first provide background to the study by briefly outlining our conception of quantitative literacy on which our quantitative literacy courses are based, describe the course for social sciences students, including its assessment, and explain our reasons for doing the study. We will then explain how we did our analysis of both the course materials and the students' performance on assessment items, discuss our results, and make some recommendations based on them.

Background to the Study

Quantitative Literacy for Social Sciences Students

Formulation of outcomes for our quantitative literacy course will naturally be determined by our beliefs about the nature of this literacy. We agree with Steen (2004) that "quantitative literacy is . . . about challenging college-level settings in which quantitative analysis is intertwined with political, scientific, historical, or artistic contexts. Here QL adds a crucial dimension of rigor and thoughtfulness to many of the issues commonly addressed in undergraduate education" (22).

Formally, we adopt the definition of quantitative literacy for higher education as a practice in which students manage situations or solve problems in academic contexts that involve responding to quantitative information, which may be presented verbally or graphically and 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 communication, in written, oral, or visual mode (Frith and Prince 2006, 30). This view rests on the conceptualisation of literacy and numeracy as social practice (Street 2000; Baynham and Baker 2002; Street 2005; Barton 2006; Kelly et al. 2007) and is similar to the definition of numeracy used by the Adult Literacy and Lifeskills Survey (Gal et al. 2005). Our definition implies that students should be able to interpret quantitative information in texts, tables, and charts and that they should be able to communicate quantitative information and arguments using appropriate language and reasoning. The definition does not specifically emphasise the importance of a critical orientation to the use of mathematics and statistics in society that is stressed by many authors (e.g., Johnston 1994; Geiger et al. 2015), but we strongly agree that it is the most important component of the "enabling behaviours" mentioned in the definition.

Thinking of quantitative literacy as practice highlights the essential role of language in this literacy. The correct expression of quantitative ideas requires the use of specific vocabulary and language forms, termed "Mathsemantics" by MacNeal (1994). For example, Schield (2008) pointed out that "The comparison of ratios, rates, and percentages in ordinary language requires using English in a very precise manner. Small changes in syntax can produce large changes in semantics" (94), and Barton (2006) found in his research on numeracy in people's everyday life that "when people talked of having difficulty with numbers . . . the language and literacy associated with numeracy were part of the issue" (29).

We also believe that, for students, quantitative literacy involves a degree of computer literacy. Although it is not explicitly stated in our definition, the ability to use a computer (in our case a spreadsheet application) to access and express quantitative information should be part of the relevant enabling knowledge, behaviours, and processes.

Reasons for the Study

The context-driven quantitative literacy course for social sciences students is provided to almost 400 students and is taught by a team of lecturers, each of whom is responsible for the delivery of course material to one of six classes. Since quantitative literacy is not a discipline in its own right, there is not a natural flow of graduates who can become lecturers with an immediate "body of knowledge" and an understanding of the issues involved in the learning and teaching of QL. Staff members in the Numeracy Centre have varied academic backgrounds—in mathematics and mathematics education, physics, and psychology—and have varying degrees of experience and understanding of the nature of quantitative literacy for university students. In the absence of clearly-articulated learning outcomes, this naturally results in some unevenness in the interpretation of the curriculum when teaching the courses and differences of opinion, particularly when it comes to designing assessments.

We (the authors) have for some time expressed concern that there may not be sufficient alignment between what we claim to do in the course, what we do in the classroom, and what we actually require of students in assessments. For example, we believe that critical reasoning is crucial to quantitative literacy, but experience some doubt about whether our teaching and assessment adequately reflect this conviction. Venkatet al. (2009) investigated similar concerns in the context of the school Mathematical Literacy curriculum, and their work provided a stimulus for us to undertake a study of these alignment issues in our course. The paper by Bae et al. (2019) provided us with some ideas about how we might begin to go about it.

We believe that this study is particularly necessary for us now because a number of the experienced lecturers in the Centre are due to retire soon and be replaced by new, probably inexperienced lecturers. It is to be hoped that the results of this study will help to ensure stability and integrity in the QL courses and provide an established base from which courses will evolve in the future. By suggesting a formal list of learning outcomes for our courses we hope to help ensure that the courses remain true to the concept of QL as a vital academic literacy. The study also provides procedures that can be implemented by the teaching team for ongoing monitoring of the alignment between the stated purposes of courses and assessment tasks. The procedure demonstrated by this study to monitor students' performance on different learning outcomes will also be useful to inform the manner in which teaching and learning is carried out. Ultimately, we also provide our analysis as a model for others who may face challenges similar to ours.

The Quantitative Literacy Course

The Quantitative Literacy for Social Sciences course is a one-semester course taken by first-year social sciences students who are either taking it as a foundation course as part of an extended programme or are obliged to do it because they did not meet the criteria for direct entry into a psychology major (in which case this course is a prerequisite for a follow-on course that provides an introduction to inferential statistics). These criteria are defined in terms of the result for Mathematics in the school-leaving examination and performance in the National Benchmark Test for quantitative literacy (Frith and Prince 2018). As noted earlier, the QL course is context-based, with many of the contexts involving social justice issues that are relevant to South African society and to students' proposed course of study. For example, students are introduced to the topic of children's rights via an overview of the Children's Act of 2005. Even though this act was passed fifteen years ago, the realisation of children's rights remains a challenge and the many scholarly and other articles written about this provide a rich source of material containing data and text suitable for the purpose of the development of quantitative literacy in social sciences students. Other contexts, such as the personality traits that influence risky driving behaviour among students, are useful for examining statistical concepts as well as being relevant to students' lives.

Each week students attend four 45-minute lecture-workshops conducted by a QL lecturer, one classroom tutorial, and one student-paced, interactive Excel tutorial where assistance in the computer laboratory is available if required. The lecture-workshops, for classes of about sixty students, usually consist of some input by the lecturer, followed by group work, when students in smaller groups of three or four engage with materials by answering comprehension-type questions about the quantitative aspects of the context. The lecturer's role then becomes one of facilitator of group discussions. Classroom tutorials, for groups of about twenty students, are facilitated by specially-trained post-graduate student tutors and provide students with further practice in engaging, in relevant contexts, with concepts that were covered in that week's lecture-workshops. The interactive Excel computer laboratory tutorials have the dual objective of teaching Excel skills while reinforcing mathematical and statistical concepts covered in workshop-lectures.

These skills and concepts are encountered as students are led through relevant contexts. The course is further described in Frith (2012).

The final mark a student obtains for the course is made up of a class record based on formative assessments, and the results from written and computer-based summative examinations.

In 2019 the class record was composed of the results of two written assessments (class tests), one written assignment, and computer tutorial submissions. The written tests took place in the fifth and ninth weeks of the twelve-week semester, covering work done in lectures in the previous weeks (each counting 32.5% of the class record). The tests typically had three or four questions, each based on a context (a newspaper article or academic publication that may be edited or adapted to enable first-year students to engage with it) relevant to society or students' disciplines. Each question then had sub-questions that assessed students'

- comprehension of the quantitative aspects of the context;
- ability to interpret data represented in various ways and confirm, where possible, values used in the article;
- ability to perform further calculations;
- written explanations of mathematical or statistical processes, or of inferences about the context that might be drawn.

The assignment required students to read given academic articles containing information about the cost of and funding for the higher education system in South Africa. Students were then required to formulate an argument, in the form of a written report, supported by data obtained from the articles, to explain whether free higher education is feasible, a highly topical question in 2019 as it has led to violent student protests in recent years. This assignment counted 15% toward the class record. Given the nature of this written assignment, some of the marks were awarded for aspects of academic literacy that are not specifically quantitative, such as the structure of the writing and correct use of referencing.

There was also a combined mark obtained from the weekly assessment of computer tutorial submissions, contributing 15% to the class record. To make up the complete class record, students were awarded a mark for attendance (up to 5%) based on their level of attendance at lecture-workshops and tutorials. This last contribution to the class record was excluded from our analysis for the purposes of this study.

At the end of the semester students wrote two summative examinations. One was a written paper that was an extended form of the earlier assessments and counted two-thirds of the examination mark. The other was a computer-based exam (lab exam) that assessed both Excel skills and quantitative literacy as described above for the paper-based assessments. This exam contributed one-third of the examination mark.

The final mark for the course was calculated using a formula where the class record counted either 70% or 30% of the final course mark, whichever was more beneficial. In 2019 the class record made up 70% of the final mark for two thirds of the students in the course. This flexible system of calculating the final course mark was introduced in response to a call for greater responsiveness to students' different learning styles and the fact that many students claim that traditional examinations do not allow them to display their full potential. Previously the class record and the examinations were weighted equally.

Methods

Formalising the Outcomes

Although there is a generally accepted definition of QL in the Numeracy Centre (see "Background to the Study" above), there have previously been no formally-stated learning outcomes for the course. The existing course outline contained in the course materials is mainly a list of mathematical and statistical content (including "writing about data" and "interpreting data in text, tables, and charts") that students encounter when engaging with relevant contexts. We (the authors) formulated learning outcomes for the course that were guided by the existing course outline and from our understanding, having taught the course and developed materials over many years, of what is done in the course and what is implicitly expected of students.

We first considered our sets of outcomes individually, then, after discussion, merged them. We found that the two sets of outcomes, although expressed differently, covered the same features, topics, and skills that we believe are important in a quantitative literacy course for first-year social sciences students in South Africa. Table 1 below shows the final set of 18 learning outcomes (LOs) that we agreed on. These include literacy competencies such as reading with understanding texts, tables, and charts that contain quantitative information and the interpretation of such information; representing data using charts and tables; writing about quantitative information by giving reasoned explanations about data and quantitative processes; and building an argument using supporting data. The mathematical and statistical competencies, indicated as being in service of the literacy competencies, include performing calculations with percentages in various forms and calculating (using Excel) and interpreting statistical measures such as those of central tendency, spread, and correlation. It is important to note here that, while we confirm that critical thinking is the cornerstone of quantitatively literate behaviour, it is not listed as a learning outcome for this course. In our experience we have come to understand that it cannot easily be activated unless the learning outcomes stated in Table 1 have been achieved. We have thus found that this challenging goal is difficult to achieve in an entry-level, single-semester course and suggest that it is not realistic to expect it as a learning outcome of this course. The habit of mind to have a critical orientation with respect to quantitative information and communication takes time and exposure to multiple situations to develop and should ideally be a learning outcome of the degree, not a single course.

Table 1
Learning Outcomes for First Semester Quantitative Literacy Course for Social Sciences

	Description	Details
Main QL Outcomes		
1	Interpreting texts containing quantitative information	Reading quantitative language with understanding; making connections between text and data representations included in the text; constructing and doing basic calculations using data from texts.
2	Interpreting data in tables	Reading tables with understanding and doing basic calculations and comparisons using values from tables.
3	Interpreting data in charts	Reading charts with understanding and doing basic calculations and comparisons using values from charts.
4	Representing data using charts and tables	Creating charts and tables; choosing appropriate representations. (This is mostly done in Excel.)
5	Representing quantitative concepts using language	Using appropriate language to express quantitative concepts, e.g., expressing the meaning of a data value in its context; selecting appropriate data to create a summary; describing trends from a table/time series chart.
6	Reasoning with data in context	Explaining proportional reasoning; absolute vs. relative change; understanding need for weighted averages.
7	Building an argument	Creating a text using identified data to support an argument (stated by the student, not given). This includes identifying relevant data and may include some calculations.
In order to achieve these outcomes:		
Calculation outcomes		
8	Recognising and representing numbers in different ways	Writing in full; scientific notation; rounding; knowing millions, billions, etc.; expressing rates as %.
9	Comparing the size of numbers in absolute and relative terms	Answering questions "how much more?", "how many times as big?"; orders of magnitude; percentage change vs. difference in percentage points.
10	Calculating with percentages	Expressing one number as a percentage of another; finding the whole when given the absolute and relative size of a subset; expressing one number as a percentage of the whole; finding percentage of a percentage.
11	Calculating with rates	Calculating the rate from the actual numbers; finding the actual number from the rate; concept of average (e.g., average annual change, average cost per house).
12	Calculating with relative change: calculating percentage change in absolute numbers and in proportions	Understanding relationship between percentage change and "how many times as big?"; increasing/decreasing by a percentage using a growth factor (including inflation and compound interest, time-value of money); calculating final (or initial) value given the rate and initial (or final) value; successive percentage increases; overall percentage increase using growth factor.
Statistics outcomes		
13	Working with probabilities	Understanding a context in order to calculate probabilities using frequency definition; "or" rule, "and" rule, etc.; comparing likelihood of events; calculating conditional probabilities from contingency tables.
14	Interpreting distributions in context	Interpreting mean and SD; quantiles; comparing distributions.
15	Describing distributions using descriptive statistics	Including calculating descriptive statistics.
16	Representing and interpreting the relationship between two variables	Including creating scatter plots and calculating correlation coefficients (in Excel).
Digital and language literacies outcomes		
17	Using Excel's capabilities	Creating charts, frequency tables; doing calculations including calculating descriptive statistics.
18	Expository writing	Using appropriate and correct academic language and structure; referencing.

Analysing Assessments

We employed a procedure similar to that reported by Bae et al. (2019). Each assessment in 2019 was analysed item by item—an item being the simplest instruction as experienced by the students. An item could form part of a larger question, requiring the demonstration of a skill, such as "Determine the percentage increase in the proportion of five-year-old children who were enrolled in Grade R [pre-school] from 2002 to 2013"; it could be a question requiring reasoning and a synthesis of information obtained from the given text, chart, and previous calculations, as well as a written communication of this process, such as "Explain, using data from the chart, whether progress was made in terms of the Millennium Development Goal to 'stop and reverse' the TB incidence rate by 2015." We acknowledge that items have different cognitive requirements, as do the various learning outcomes.

Our method differed from that of Bae et al. (2019) in that an item could be mapped to up to four different LOs, where they allowed only two. Another difference is that in our analysis each LO could have a differently-weighted contribution to the item (not only 50% or 100%). This weighting was based on a judgement of the relative importance of the constituent outcomes, and in this we were guided by the manner in which marks were allocated to a correct answer in the marking memorandum. So, for example, an item that required a student to "Describe, in context, all the information that is given by the point A on the graph" was coded as 5–100% (outcome 5 requires using appropriate language to express quantitative concepts). An item that required students to find two appropriate values embedded in a text and calculate the percentage change would be coded as 1–50%, 12–50% if it was agreed that finding the two associated values required greater understanding of the context than a similar question where the two values were more easily extracted from a table, say, in which case the coding was 2–25%, 12–75%. (Outcome 1 is "Interpreting text," outcome 2 is "Interpreting tables," and outcome 12 is "Calculating with relative change"). Examples of coded items for the different outcomes are given in the Appendix.

We (separately) analysed each assessment and coded each item according to the LOs that it addressed and the weighting of the LOs in the item. We then compared and discussed the coding given until agreement was reached. In most cases, agreement was reached with little discussion required.

Once we had completed this coding exercise to establish the proportions of each item that were devoted to particular outcomes, we took the work of Bae et al. (2019) further and used these proportions and the marks available for each item to calculate the total marks devoted to each outcome, first for each assessment, and then for the final course mark as a whole.

Analysing Student Results

The marks awarded for each item in each assessment were recorded for every student who wrote that assessment (the number of students varied, ranging from 368 writing test 1 to 354 writing the examinations). We then calculated the average mark achieved by the students for each item. These average marks for each item were then divided between the outcomes assigned to that item in the ratios that were decided during the coding exercise described above. In this way we established the average number of marks achieved for each outcome. We used these to calculate an average performance for each outcome (as a percentage) by dividing the average number of marks achieved by the total number of marks assigned to that outcome in the coding exercise. For each assessment we calculated the difference between the average performance for each outcome and the average performance on the test as a whole. This was done to reveal outcomes in which students performed relatively well and relatively poorly.

Results and Discussion

Learning Outcomes of the Course

The learning outcomes that we formalised in the first stage of our research are listed in Table 1. The first seven outcomes listed are the main QL outcomes that are the backbone of the course. They involve the higher order competencies of interpretation, communication (including accurate use of language expressing quantitative concepts), and reasoning. We recognise that these outcomes are not mutually exclusive, in that higher order competencies such as building an argument (outcome 7) clearly require competencies such as expressing quantitative ideas (outcome 5) and reasoning (outcome 6). So, for example, an item coded as addressing outcome 6 (reasoning) would not be coded as addressing outcome 5 as well, and an item that is coded as addressing outcome 7 (building an argument) would not be coded as addressing outcomes 5 and 6 as well.

We consider outcomes 8 to 17 to be necessary in order to achieve the main QL outcomes. They have to do with knowledge of specific quantitative concepts, the ability to perform calculations, and to use the spreadsheet application Excel. Outcome 18 takes care of academic competencies that are not overtly quantitative in nature (expository writing) but are a necessary part of academic communication. Outcomes 8 to 18 are grouped under the headings “Calculation outcomes,” “Statistics outcomes,” and “Digital and language literacies outcomes.”

Outcomes Reflected in the Assessments

In this section we report on how the learning outcomes were distributed across the assessments and discuss the extent to which the assessment questions were aligned with the learning outcomes. This section (and the one that follows, on student performance) highlights ways to assist lecturers to monitor and control the alignment between outcomes, teaching and learning activities, and assessments by using our analysis of the 2019 assessments as examples.

We first consider the allocation of marks to each of the outcomes separately. Figure 1 shows the percentage of the total marks for each of the 18 outcomes in each assessment. The outcomes are grouped and presented in three charts so that the whole percentage distribution (by outcome) for each type of assessment is made up of the three distributions (aligned vertically). For example, 23% of the marks for the assignment were for interpreting text, 35% for building an argument (in the top chart), and 43% for expository writing (in the bottom chart) making a total of 100%.

Some observations are presented below to illustrate how an analysis like this can be useful in assisting lecturers to monitor the alignment between course outcomes, teaching and learning activities, and assessment (especially if the analysis is done as an ongoing, routine part of designing assessments).

If we consider the percentages of marks devoted to the first three outcomes in Test 1, we see that interpreting text was weighted much more heavily than interpreting charts or tables. This is an imbalance since significant time was also spent in the classroom and in the Excel tutorials on interpreting tables and charts. An imbalance like this can easily arise due to the constraints of finding suitable authentic contextual material on which to base assessment questions that include a variety of data representations. The kind of analysis shown in Figure 1 (if done timeously) should alert lecturers to the need to compensate for this kind of imbalance in subsequent assessments. In fact, we see from the top chart in Figure 1 that interpretation of charts (outcome 3) was relatively under-represented in all assessments in 2019.

In the middle chart in Figure 1, showing the "calculating" outcomes, we see that in all tests and the written exam "Calculating: percentage change" was heavily represented. This is probably appropriate as in the course we focussed heavily on percentage change, including the calculation of the real value of money (taking inflation into account), which students find challenging.

In the bottom chart in Figure 1 we observe that in the Excel-based exam, half the marks were awarded for successfully using Excel to perform calculations and create tables and charts (Excel skills). This is appropriate, as the objectives of the Excel tutorials were equally to learn how to use a spreadsheet and to use the spreadsheet to support learning of quantitative concepts.

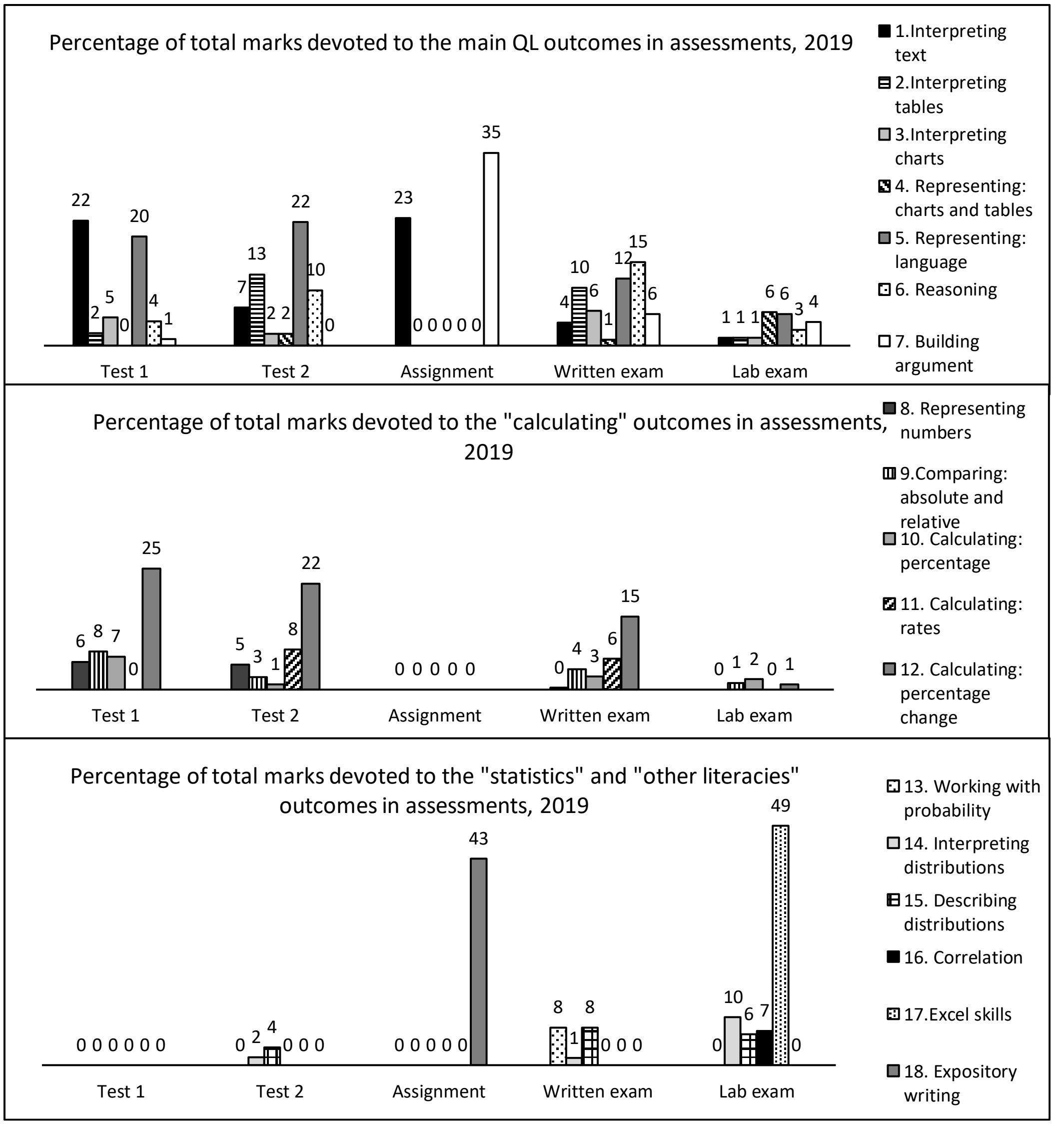

Figure 1. Percentage distribution of marks in each 2019 assessment by outcome. Total distribution for each assessment is split vertically over the three charts (showing different groups of outcomes).

We now consider the allocation of marks to groups of outcomes. The percentage distribution of the marks allocated in each assessment and in the final course mark to the different groups of outcomes is shown in Table 2. Outcomes 17 and 18 are recorded separately as they reflect very different types of competencies.

Table 2 shows that the percentage of assessment marks devoted to the main QL outcomes (numbers 1 to 7) was consistently in the region of 55%, except in the Excel exam where half the marks were for Excel skills. This means that in the final mark calculation just under 50% was devoted to the main QL outcomes. Two questions the course teaching team needs to consider are: does this proportion reflect what we believe to be the relative importance of these outcomes in our course? and are these proportions in line with the time we spend on these outcomes in class?

Table 2
Percentage of Marks in the 2019 Assessments Devoted to the Main Groups of Outcomes

	Main QL outcomes 1–7	Calculation outcomes 8–12	Statistics outcomes 13–16	Excel skills: outcome 17	Non-QL academic literacy: outcome 18
Test 1	55	45	0	0	0
Test 2	56	39	5	0	0
Written exam	54	29	17	0	0
Excel exam	23	5	23	49	0
Assignment	58	0	0	0	43
FINAL MARK					
30:70*	**46**	**24**	**15**	**14**	**2**
70:30	**48.5**	**27**	**9.5**	**10**	**4.7**

* The final mark was calculated using the class record as either 30% or 70% of the total, whichever gave the better result.

This table also shows that about a quarter of the final course mark was devoted to the calculation outcomes (numbers 8 to 12). The percentage for these outcomes was much higher than 25% in the first test (45%), declining as the course progressed to 29% in the written exam and only 5% in the Excel exam. This reduction in a focus on lower order calculation competencies is to be expected as the expectations for students to handle higher order questions should increase as the course progresses. Consideration of the same questions mentioned in the previous paragraph would be relevant here, for the teaching team to monitor alignment in the course.

The statistics outcomes (numbers 13 to 16) were relatively under-represented when compared to the time devoted to statistics topics during the teaching of the course. Approximately four weeks of the twelve-week semester were used to teach statistics, but the statistics outcomes account for at most 15% of a student's final mark. In addition, these outcomes were represented almost entirely in the two exams because statistical concepts were taught mostly after the second class test was written. This means that the 67% of students whose final mark was calculated using the class record counting 70% had just under 10% of their marks devoted to statistics outcomes. As a result, many students could have passed the course without displaying any knowledge of the statistics outcomes at all. This is obviously not desirable, as a third of the teaching time in the course was devoted to these topics. It is especially problematic as many students who passed this course proceeded to the follow-on semester course on quantitative research methods, where a basic knowledge of descriptive statistics was assumed.

Competence in using Excel (outcome 17) accounted for 10% or 14% of the final course mark, depending on which calculation was used. Given that students spent 20% of their class time in the computer laboratory and the purpose of the Excel tutorials is equally to learn Excel skills and to use the spreadsheet to support learning of quantitative concepts, it seems appropriate that in the region of 10% of the course credit should be for Excel skills.

Academic literacy that is not quantitative accounted for up to nearly 5% of the final course mark for those whose class record counted 70%. These marks were awarded for aspects of writing in the assignment, such as structure and referencing, which are obviously important, but not overtly quantitative in nature. Amongst the lecturers on the teaching team there is disagreement about the importance of the development of these skills in a QL course, so producing quantitative evidence like ours can potentially inform the debate productively.

Student Performance in Assessments

In this section we address the question "To what extent did students achieve the learning outcomes in 2019?" and consider how the answer to this question could be used by lecturers to improve alignment in the course. The charts in Figure 2 show performance on each outcome relative to the average for each test separately. In interpreting these results we need to be careful when trying to compare performance between tests. For example, for outcome 1, students did slightly better than average in test 2 and worse than average on the lab exam, but this could be a reflection of the differences between the nature of the assessments and the difficulty level of the other questions in each of them, and not a reflection of a change in students' abilities.

Unfortunately, these charts do not reflect the proportions of the test devoted to any particular outcome, which needs to be taken into account when interpreting them. For example, students did relatively poorly in Test 1 (top chart) on "reasoning" (outcome 6), getting about 30% on average (32 percentage points below 62%). In this test there were only two questions that addressed this outcome, with most of the marks coming from a question requiring the explanation of proportional reasoning, which is known to be difficult for students (Lloyd and Frith 2016). So it is not surprising that performance on this outcome was relatively poor, especially since this was early in the course.

From these charts we can see for which outcomes students performed better or worse in all or most assessments, giving some sense of the overall success of the course in achieving its objectives. For example, students did relatively well on interpreting and representing quantitative information (outcomes 2 to 5), representing numbers (outcome 8), and on Excel skills (outcome 17).

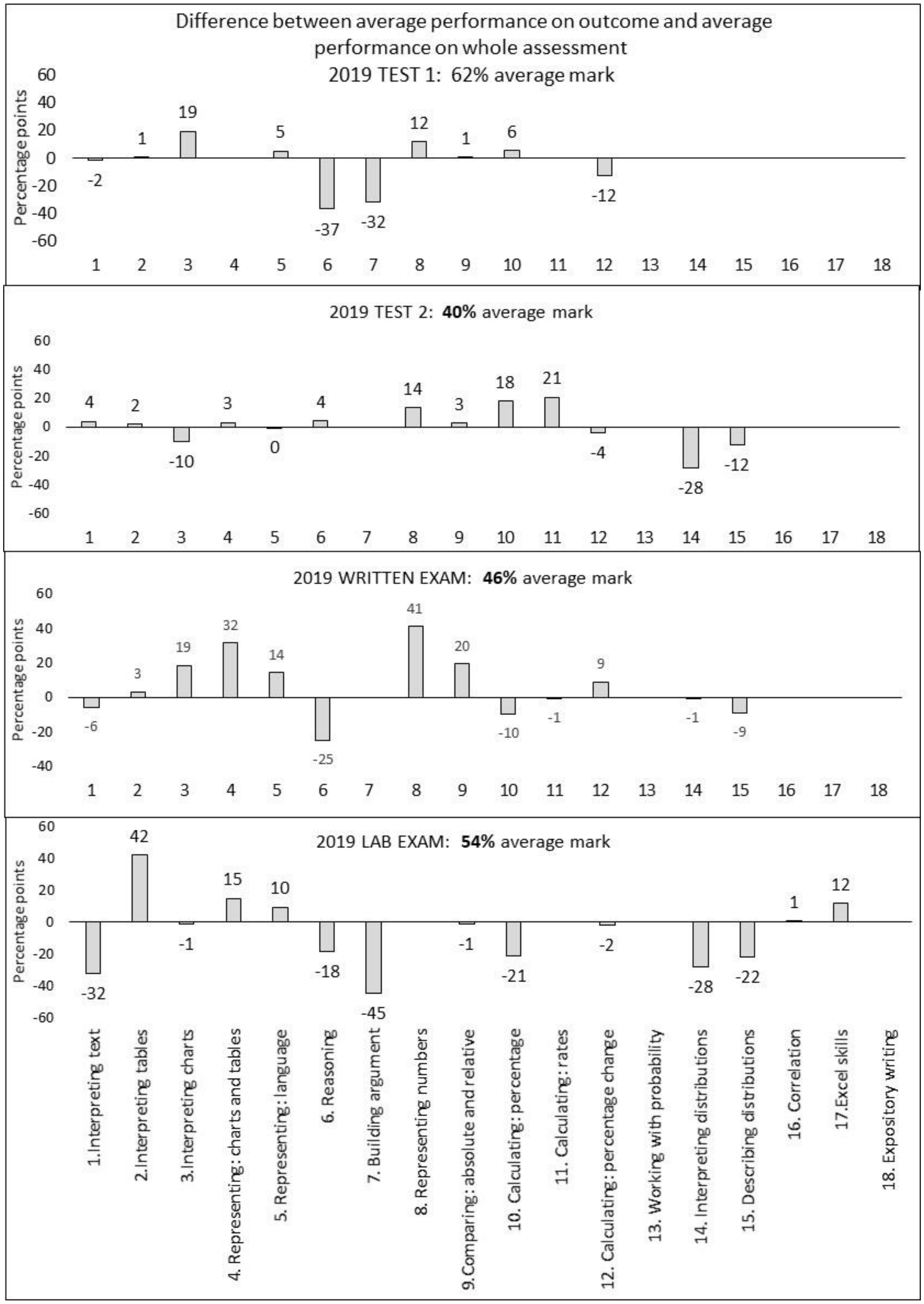

Figure 2. Difference between class average performance for each outcome and class average for whole assessment.

On the other hand, they did relatively poorly on reasoning and building an argument (outcomes 6 and 7), calculating percentage change (outcome 12), and statistics (outcomes 14 and 15). It is not surprising that they did relatively badly on questions requiring reasoning and building an argument, as these would be some of the most challenging in any assessment. However, it is worth thinking about how the teaching and learning activities in the course can be changed to address outcomes 12, 14, and 15 more effectively. Percentage change calculations were strongly emphasised in this course, but clearly the considerable time and effort devoted to this outcome in class was not as effective as we would like. This should also prompt a reconsideration of how we teach this outcome. Regarding the statistics outcomes (14 and 15), we know from experience that many students for various reasons stop actively participating in the course in the last few weeks of the semester, which is when we currently address these outcomes. Thus, we are aware that students generally do not do well on the statistics questions, but the analysis we report in this paper provides some quantitative, and hence usually more persuasive, evidence that we need to introduce a suitable response to this problem.

Summary and Conclusions

We analysed the assessment items and student performance in assessments in one iteration of our quantitative literacy course for social sciences students in order to investigate the extent of alignment between our goals and our assessments, and to inform our attempt to improve alignment between outcomes, teaching, and assessment. This exercise revealed useful insights and suggested procedures that could be implemented for ongoing monitoring of course alignment. For example, we found that in our assessments in 2019 interpreting text was weighted much more heavily than interpreting charts or tables. An ongoing monitoring procedure based on what we did in this study would be useful to avoid such imbalances in the future.

This research raised questions for the teaching team that could be productive. For instance, we found that just under 50% of the final mark was devoted to the main QL outcomes and about a quarter was devoted to the calculation outcomes. This provides a basis for discussing whether our assessment reflects what we believe to be the relative importance of these outcomes and the emphasis they receive in our teaching. Other results that merit further discussion within the course teaching team are that expository writing (academic literacy that is not overtly quantitative) accounts for up to nearly 5% of final course mark for the two thirds of the students whose class record was weighed heavily and that competence in using Excel accounted for 10 or 14% of final course mark.

The most important insight we obtained about our course as a result of this analysis relates to the statistics outcomes. The statistics outcomes were under-represented in the make-up of the overall course mark and assessment of these outcomes was restricted almost entirely to the two exams. This means that more than half of the students could potentially pass the course without displaying any knowledge of the statistics outcomes at all. In addition, the statistics outcomes were some of those in which the students displayed consistently relatively poor performance. This problem in the course clearly needs to be addressed, as many students who are successful in this course proceed to the follow-on semester course on quantitative research methods, where a basic knowledge of descriptive statistics is assumed.

Our research has demonstrated how implementing an ongoing monitoring of course assessments in a quantitative literacy course is useful for the teaching staff to ensure better alignment between course goals and assessment. The techniques employed also reveal the relative weighting of the different groups of course outcomes in the course assessment as a whole and can be used to inform discussion of whether these weightings reflect lecturers' views of the relative importance of the outcomes. Our study has taken the research done by others further by analysing student performance on different learning outcomes. These measures can provide the impetus to examine and monitor more closely the teaching and learning of concepts that are challenging to students. We trust that our discussion of our experience may be the stimulus for others to introduce similar monitoring for the purpose of improving alignment in their QL courses.

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Appendix

Examples of Assessment Items Representing the Various Outcomes

Table 3 shows example items for each of the outcomes (see Table 1). The contextual materials that the questions refer to are given below the table.

Table 3
Examples of items assessing different outcomes:

Item	Out-come	%	
Test 1 q1.5a	**1**	100	In total, how much money was paid to all caregivers of children in foster care in 2017? *(all required data in the text—see below)*
Test 1q1.1	**2** 8	50 50	Referring to the Table, in which province was there an increase in the number of children receiving the FCG between 2012 and 2018?
Test 1 q1.2	**5**	100	Describe in words what the entry '-28' in the last column of Table 1 informs us about the context.
Test 1 q1.4a	**6**	100	Explain why 22% is not the average of the percentage changes experienced by provinces in Table 1.
Test 1 q1.5b	**8**	100	Round your answer in (a) to the nearest billion.
Test 1 q1.7	1 **12**	25 75	Calculate the percentage change in the number of children receiving the Foster Care Grant from 2012 to 2017.
Test 1 q1.6	1 **10**	25 75	Calculate the total number of children who received the FCG in 2014.
Test 1 q2.1	**3** 5	50 50	Write a sentence that describes all the information provided by the segment of the pie indicated by the arrow in Figure 1.
Test 1 q2.3	3 **9**	10 90	Find the absolute difference in the proportional contributions to total sales of electricity in the first quarter of 2015 by KwaZulu-Natal and Limpopo.
Exam q1 (c)	1 **4**	25 75	The relative proportions of new cases of TB in the regions of the world in 2017 is described in the first paragraph of the text. Say what kind of chart would be most suitable for representing this information and explain your choice.
Exam q1 (j)	**7**	100	Explain using data from the chart whether progress was made in South Africa and in the world in terms of the Millennium Development Goal to "stop and reverse" the TB incidence rate by 2015.
Exam q1 (f)	2 **11**	25 75	Calculate the incidence rate in China in 2017.
Exam q5A (e)	6 **13**	25 75	In a report on enrolments in higher education, it is noted that female students are more likely than male students to study at distance-learning institutions. Explain, using calculations, whether or not this statement is true.
Excel exam q 4.4	**16**	100	Describe the relationship between the percentage of students who scored 50% or above in English and the percentage of students who scored 50% or above in Mathematics among the high schools of Gauteng East. *(question follows drawing the scatter plot and calculating the correlation coefficient)*
Excel exam q 5.4	**17**	100	Make a bar chart of the frequency table [you drew up in question 3 above].
Excel exam q 5.5	**15**	100	Describe the distribution represented in the chart you made in question 5.4 above.
Excel exam q 6.4	**14**	100	Use your box-and-whisker plots to compare the distributions of the proportions between English Home Language and isiZulu Home Language.

Contextual Materials Provided to Students as Part of the Test and Exam Questions Referred to in Table 3 Above

Materials for Test 1, Question 1. The extract below is sourced from: Hall, K. & Sambu, W. (2018). “Income Poverty, Unemployment and Social Grants.” In K. Hall, L. Richter, Z. Mokomane, & L. Lake (Eds.), *South African Child Gauge 2018*: *Children, Families and the State Collaboration and Contestation.* Cape Town: Children’s Institute, University of Cape Town.

The Foster Care Grant (FCG) is available to foster parents who have a child placed in their care by an order of the court. It is a cash grant, that is valued at R920 per month in 2017. The grant is intended as financial support for children removed from their families and placed in foster care for protection in situations of abuse or neglect.

Since 2012 the number of FCGs has declined, in part because there has been a substantial increase in the number of grants that terminate at the end of each year, when children turn 18. At the end of 2014, 300 000 of the children had turned 18, representing about 60% of all children receiving the FCG. In 2017, 440 000 FCGs were paid each month to caregivers of children in foster care, substantially down from 536 747 grants paid each month in 2012.

Table 1 below shows more information about children receiving the Foster Care Grant in the years 2012 and 2018.

Table 1
Number of Children Receiving the Foster Care Grant by Province, 2012 & 2018

Province	2012	2018	Absolute change	Relative change (%)
Eastern Cape			-17 793	-15
Free State	43 311	30 991	-12 320	**-28**
Gauteng			-8 319	-15
KwaZulu-Natal	142 114	83 525	-58 589	-41
Limpopo	56 066	46 341	-9 725	-17
Mpumalanga	32 886	30 351	-2 535	-8
North West	45 634	33 094	-12 540	-27
Northern Cape	14 456	12 880	-1 576	-11
Western Cape	29 003		2 666	
South Africa	**536 747**	**416 016**	**-120 731**	**-22**

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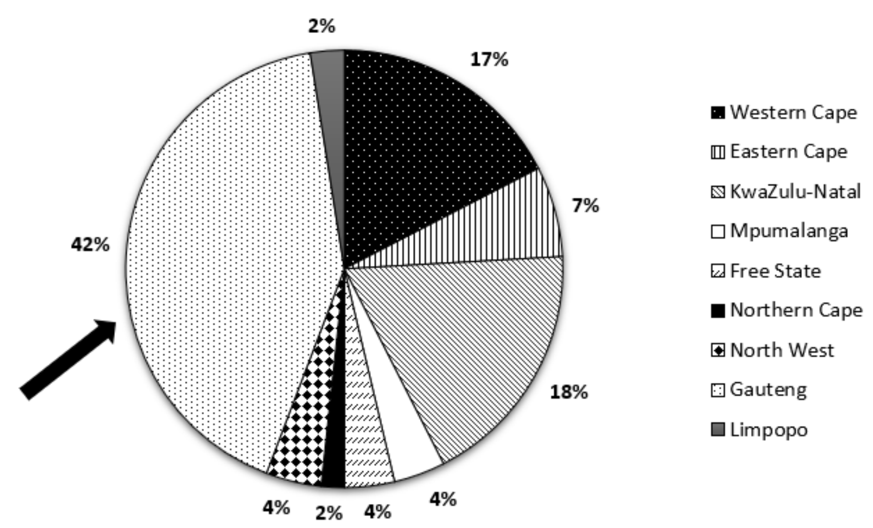
Materials for Test 1, Question 2. *Loadshedding is contributing to lost revenue for South African municipalities.*

> ***Note about the distribution of electricity by municipalities:***
> *Each municipality in the country purchases electricity from Eskom in order to sell it on to the households and businesses in that municipality.*

The Quarterly Financial Statistics of Municipalities Report stated that the purchase of electricity from Eskom by all municipalities in the country went down from R13 210 million in December 2014 to R12 623 million in March 2015. Even though total electricity sales by municipalities dropped by 3.8% to R20 301 million in the first quarter of 2015, income from the sale of electricity remains the largest contributor, at 25.8%, to the total income of South African municipalities.

The chart below shows the fraction of the total electricity sales contributed by the municipalities in each province.

Figure 1: Proportion of total municipal sales of electricity contributed by each province in South Africa, First Quarter, 2015



Materials for Written Exam Question 1. *The following text and data are adapted from the World Health Organisation's Global Tuberculosis Reports. (https://www.who.int/tb/publications/global_report/archive/en/)*

In 2017, there were an estimated 10 million new (incident) cases of tuberculosis (TB) in the world, equivalent to 133 cases per 100 000 people in the population. Most of the estimated number of new cases in 2017 occurred in the South-East Asia Region (44%), the African Region (25%), and the Western Pacific Region (18%); smaller proportions of cases occurred in the Eastern Mediterranean Region (7.6%), the Region of the Americas (2.8%), and the European Region (2.6%).

Eight countries accounted for two thirds of the world total number of new cases of TB: India (27%), China (9%), Indonesia (8%), the Philippines (6%), Pakistan (5%), Nigeria (4%), Bangladesh (4%), and South Africa (3%).

An estimated 9% of the new TB cases in 2017 were among people living with HIV. The proportion of new TB cases who were HIV-positive was highest in countries in Africa, for example it was 60% in South Africa.

Table 1 shows TB incidence data for selected countries in 2017.

Table 1
Number of New Cases of TB and Incidence Rate in Selected Countries of the World, 2017

	Population	Number of new TB cases	Incidence rate (new cases per 100 000)
China	1 410 000 000	889 000	
DR Congo	81 000 000	262 000	
Korea	25 000 000	131 000	513
India		2 740 000	204
Kenya	50 000 0000	158 000	319
Lesotho	2 000 000	15 000	665
Liberia	5 000 000	15 400	308
Mozambique		163 000	560
Namibia	3 000 000	11 000	423
South Africa	57 000 000	322 000	565
The World	7 520 000 000	10 000 000	133

From 2000 to 2015, global and national efforts to reduce the burden of tuberculosis (TB) were focused on achieving targets that were set as part of the Millennium Development Goals of the United Nations. Target 6c was to "stop and reverse" the TB incidence rate by 2015. Figure 1 shows the TB incidence rates in South Africa and the world from 2000 to 2017.

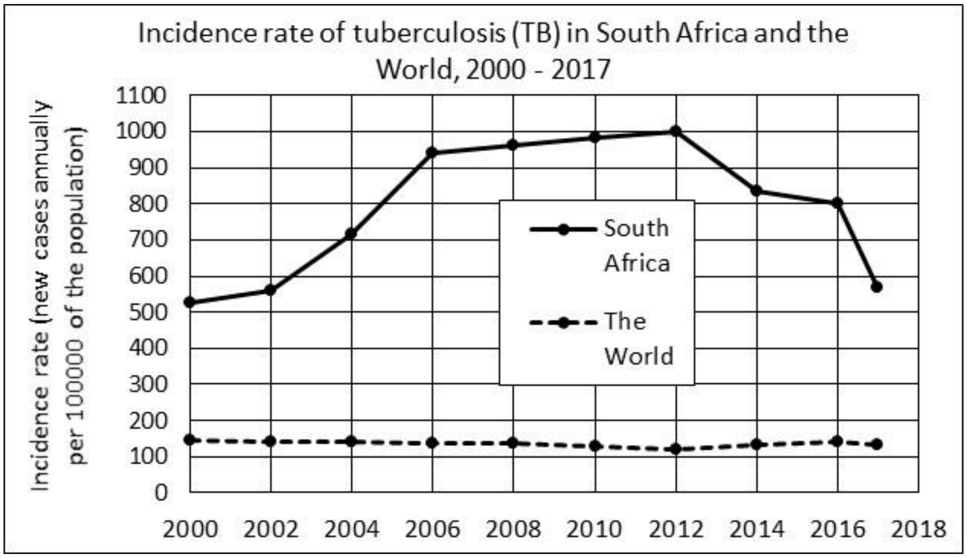


Figure 1. TB incidence rates in South Africa and the world from 2000 to 2017.

Materials for Written Exam Question 5A. Table 3 provides overall enrolment data for students in higher education institutions in South Africa in 2014, by mode of delivery (contact learning or distance learning) and gender.

Table 3
Numbers of HE Students by Mode of Delivery and Gender, 2014

		Mode of delivery		
		Contact	**Distance**	**Total**
Gender	**Male**	273 243	131 017	404 260
	Female	323 577	241 124	564 701
	Total	596 820	372 141	968 961