Curricular goals: lecturers' beliefs concerning in-service undergraduate statistics education

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This paper focuses on university lecturers' planning of undergraduate statistics education. In particular, this study explored aspects of lecturers' intended curricula such as how lecturers interpret the learning outcomes of statistics courses, their beliefs about specific topics, about teaching approaches and students' learning of statistics at university. Interview data from interviews with twenty statistical methods lecturers using the repertory grid interviewing technique was used to identify the participants' curricular goals and beliefs when planning their teaching practices. This data suggested a statistical reasoning curriculum that emphasised 'basic' statistical techniques and non-statistical skills, with an emphasis on content rather than intended learning outcomes. This paper discusses implications of the methodological approach and findings.

Keywords: statistics education; repertory grid interviewing technique

Introduction

In the last decades, reforms in statistics teaching and learning have dominated the statistics education research literature. In tertiary statistics education, research since the early 1990s has made recommendations for changes in the intended statistics curricula and key learning goals in introductory statistics (Cobb & Moore, 1997). Despite important progress made in defining key curricular goals in undergraduate statistics education, over the last four decades, statistics has remained a challenging subject for lecturers to teach and for students to learn (Garfield, delMas & Zieffler, 2012). Further, at the tertiary level, statistics courses for non-statisticians, i.e. students who take a compulsory introductory statistics course, face particular challenges (Gordon, 2004). Previous research in mathematics and statistics education, particularly at the school-level, recognised the importance of the curriculum context in which teaching and learning takes place (Thompson, 1984). It is possible that by looking more closely into lecturers' beliefs about their intended curricula, we can draw attention to the key role of the teacher in the education system (Pajares, 1992).

This paper presents an empirical study into lecturers' beliefs and conceptions about the undergraduate statistics curriculum using interviews with twenty statistical methods lecturers from a range of disciplines. The study used the repertory grid technique, based on the following questions: RQ1: What is the content of the curriculum of undergraduate statistics?; RQ2: Does the participants' intended curriculum fit the official (written) curriculum?; RQ3: What characterises the participants' beliefs regarding the teaching of statistics at university?; RQ4: What are the learning outcomes (LO) of the undergraduate statistics?; RQ5: Is there variation in the way these lecturers conceptualise the statistics curriculum?. For brevity, only three RQs are discussed here, namely RQ1-3. This study is part of a larger study examining the relationships between lecturers' beliefs about statistics and the teaching of undergraduate statistics.

Literature review

Teachers' belief systems, composed of 'beliefs connected to one another and to other cognitive/affective structures' (Pajares, 1992, p. 316), reflect their personal beliefs or attitudes about education, about the subject matter and about the students. The Second International Study of Mathematics (SIMS) considered that analysing intended curricula (official curricular goals) might help interpret the findings of the classroom processes (implemented or enacted curriculum) and student outcomes (attained curriculum) and the relationships between these three elements (IAEEA, 1979). In statistics education, a small number of empirical studies have investigated teachers' conceptions about statistics, teachers' beliefs about teaching goals and teachers' planning of statistics teaching at the elementary (primary) or secondary school levels. Eichler (2007) for example proposed that the content of statistics instruction, the teachers' objectives of statistics instruction, their beliefs about the students' benefits of statistics instruction, and about effective teaching of mathematics shape teachers' curricular planning. In another study that investigated secondary teachers' intended (individual) curricula in terms of content and learning objectives, Eichler (2008) found that although the content across the four participating teachers was similar, their learning objectives (intentions) were different.

Studies on tertiary statistics teaching investigated lecturers' conceptions and beliefs about their teaching and about their students, defining components of statistical reasoning and thinking and the development of statistics curriculum content. Gordon, Petocz and Reid (2007) focused on lecturers' conceptions of teaching of statistics to non-statisticians. The authors found that the participants had a range of conceptions about teaching statistics, from a focus on the teacher, the subject matter and course content to a broader focus on the student and their future profession, which were influenced by the contexts, cultures, values, resources and constraints surrounding their teaching. Other studies sought to identify lecturers' views about topics in undergraduate statistics (Gardner & Hudson, 1999). These research studies either focused on lecturers' situated experiences of teaching statistics or on itemising content while ignoring the context and other curricular elements. In the present study therefore, we aimed to relate statistics lecturers' beliefs and conceptions about teaching statistics with the content and LOs of statistics courses.

Methods

The repertory grid technique

In this research study we focused on lecturers' beliefs and conceptions about their intended statistics curricula. We considered the repertory grid technique (RGT) to be a suitable methodology for identifying lecturers' subjective beliefs. RGT, initially developed in clinical psychology for providing therapy to individuals, has been adapted to capture tacit knowledge in a domain for a range of applications, including education (Fransella, Bell & Bannister, 2004; Kelly, 1955). A *grid* comprises elements as column headings, constructs as rows and ratings linking an element to a construct. *Elements* are the object of study within a specific domain, e.g. statistical skills and knowledge. Bipolar *constructs* have two ends, a *positive construct* and a *negative construct*, such as 'good with numbers' (positive) versus 'bad with numbers' (negative). Participants elicit constructs by interpreting or comparing the elements, e.g. in the triadic version by comparing three elements.

Interview design and participants

Our study comprised of two interview designs, each scheduled to last one hour, shown in the diagram in Figure 1 below. Interviews started with a brief introduction into the purpose of the interview and the definition of statistical literacy, reasoning and thinking (Ben-Zvi & Garfield, 2004, p. 7). The first interview design comprised four steps (Figure 1). Step 1 asked the participants to articulate their own elements or objects of interest (such as statistical skills and knowledge, LOs or content) in terms of a specific module and student cohort.

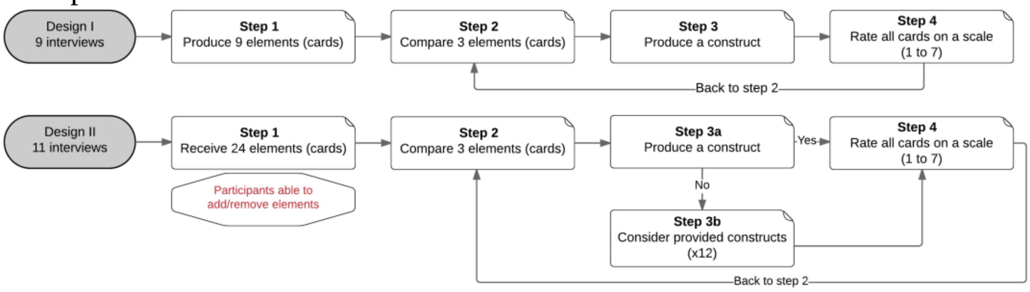

Figure 1. Repertory grid interview designs I and II

A list of statistical skills, knowledge and understanding identified by lecturers on these modules was likely to help us gather some empirical evidence for what lecturers considered important when defining curriculum and teaching statistics. The participants' teaching/learning intentions were written on nine separate cards. In step 2, the participants compared three elements (written on cards) and considered the following question: *'In terms of the skills, knowledge and understanding you would want the students on your module to learn by the end of their studies, which two cards are alike and different from the third?'* to produce a construct (step 3). Finally, in step 4, the participants rated the nine elements against a construct on a 7-point scale. The process was repeated until the participant was unable to produce any further constructs. Table 1 shows an example of a RG from one participant.

Table 1. An example of a repertory grid from one participant

Construct (positive pole)	Elements*									Construct (negative pole)
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	
C_{1+} E_3 is interpreted using E_5	1	7	1	7	2	7	6	1	6	qualitative interpretation C_{1-}
C_{2+} description and interpretation of data	7	6	4	1	6	1	4	4	1	inferential stats C_{2-}
C_{3+} analysing and interpreting data	3	7	4	1	3	1	3	2	1	sampling C_{3-}
C_{4+} methods of analysis	1	7	1	3	1	4	1	1	4	sampling C_{4-}
C_{5+} interpretation of data and stats, what it means	7	6	6	1	2	5	4	7	1	analytical method, mechanics of doing it C_{5-}
C_{6+} qualitative description & interpretation	7	2	6	1	7	1	4	7	1	quantitative description C_{6-}
C_{7+} techniques	1	2	1	6	7	2	4	1	7	how to interpret results of analysis C_{7-}
C_{8+} inferential	1	4	2	6	1	7	3	2	4	descriptive C_{8-}
C_{9+} interpreting results and what they mean	7	5	6	1	2	5	4	7	1	applying techniques C_{9-}
C_{10+} simple methods	7	2	7	1	6	1	2	4	2	more complex methods C_{10-}
C_{11+} method/design	1	1	1	7	7	2	4	1	7	interpreting results C_{11-}
C_{12+} method	1	3	1	6	4	1	3	1	7	being critical C_{12-}
C_{13+} understanding data	1	7	1	1	1	1	1	1	1	collecting data C_{13-}
C_{14+} low level	4	2	5	3	5	1	3	4	6	high level C_{14-}

*The participant elicited nine elements (cards) as follows:
E_1: be able to use simple inferential statistics;
E_2: appreciate different sampling methods - when each might be used ;
E_3: have a basic appreciation of multivariate methods;
E_4: be able to interpret graphs and tables and draw reasonable conclusions;
E_5: understand confidence intervals;
E_6: be able to describe data using descriptive statistics and appreciate graphical methods;
E_7: be able to apply correlation methods and interpret results;
E_8: be able to apply regression analysis;
E_9: be critical when interpreting data and stats given to students (e.g. in media).

In the *second design*, we used a summary of elements and constructs emerging from the first interview design. Steps 1 and 3 differed slightly from the first design. We first provided participants with a list of twenty-four elements (step 1). Participants could add/remove elements depending on their own context. Once the participants compared three elements in terms of this question, they either produced a new construct (step 3a) or considered an existing construct (step 3b). RGT was therefore used firstly to elicit lecturers' teaching intentions (the elements written on cards) and secondly to use these to elicit beliefs and conceptions about statistics (the bipolar constructs). The study involved twenty statistical methods lecturers (three from Business and Economics, six from Psychology and Sociology, five from Social

Sciences, three from Geography, two in Engineering and one from Mathematics). To collect the interview data, we deliberately invited lecturers to participate if they were teaching on a quantitative or statistics methods modules. RGT allowed these lecturers to construe in their own words what teaching statistics meant for them in relation to their own contexts.

Data analysis

The RGT resulted in both qualitative (words) and quantitative data (ratings) which was analysed to reveal the overall pattern(s) in the ratings. Each participant produced a grid, analysed separately as a case study. The data analysis procedures involved two stages. In the *first stage*, quantitative data were analysed for each interviewee using Idiogrid 4 software to undertake singular-value decomposition (SVD) as a data summary tool. SVD enables both elements and constructs to be represented together (Grice, 2002). The analysis reports distances between constructs showing the likelihood that constructs appear near each other by chance. Further, for each grid, cognitive maps group constructs with similar meanings together into clusters and elements relating to those clusters. To ensure the validity of the procedures, we also checked the plots against the grid data to ensure patterns were fairly consistent across the two. Figure 2 shows such a SVD plot which shows the elements (red dots and black font) and the constructs (blue dots and font). This participant construed the element ‘difference between descriptive and inferential statistics’ as being ‘crucial to the curriculum’, ‘easier to grasp’, ‘introductory concept’ about ‘theoretical underpinnings of statistics’ and with ‘value in the job market’. Similarly, ‘team work’ was a non-statistical skill, closely related to ‘communication and interpretation skills’. In this participant’s view, the ‘ability to understand and read quantitative research papers’ does ‘not require hand calculations’ as it is about ‘reporting’ skills.

Once we were able to group constructs and elements, in the *second phase*, we analysed the qualitative data as follows: (RQ1) expectations for statistical reasoning; (RQ2) the sequential process components of the statistical investigative process: formulate research questions, collect data, analyse data and interpret results; and (RQ3) we compared overall the modules’ LOs with the grid data. The module specifications were summarised in a database, containing the following fields: subject domain, module title, level, credit rating, aims, LOs and content.

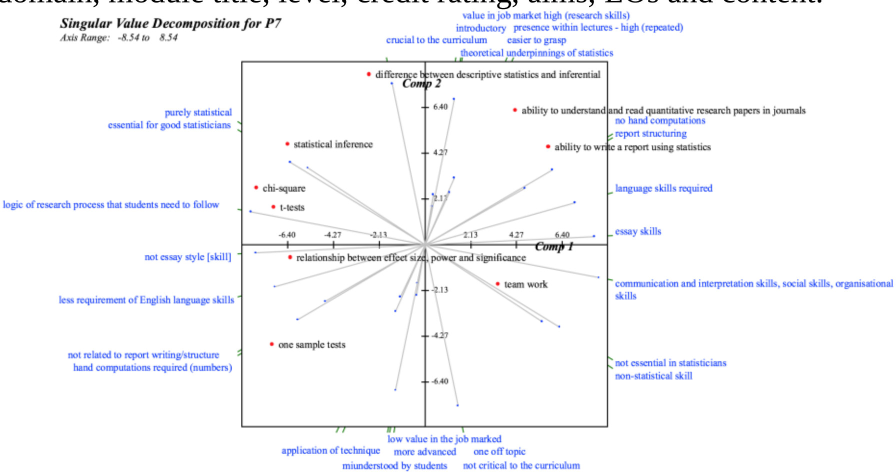

Figure 2. Singular-value decomposition plot for repertory grid ratings of one participant

Findings

The data analysis involved a complex set of procedures, which revealed that our participants focused simultaneously on curricular content, outcomes, pedagogic and contextual issues when construing their own intended curriculum.

Expectation of statistical reasoning/thinking (RQ1)

Although all statistics modules included at least one LO that promoted *statistical reasoning*, out of the 241 classifications, 21% (52) involved statistical reasoning. This may mean that, based on our interpretation of these LOs, statistical procedures rather than statistical reasoning, conceptual understanding or conducting statistical studies were emphasised in the module LOs included here. Of the 81 elements, 18 (19%) were classified as requiring statistical reasoning. Using the SVD plots, each pair of element-construct was also coded into the four statistical process components. The results of this analysis suggest that the proportion of statistical reasoning was 34% of classifications. This may mean that although there was less expectation of statistical reasoning in the module LOs and the elements and constructs when considered in isolation, the participants in fact described the elements as involving a higher proportion of statistical reasoning when considered together with their constructs.

Classification into statistical process components (RQ2)

The classifications of the 197 actual LOs into the four statistical process components (formulate research questions, collect data, analyse data, interpret data) revealed that *analysing data* involved 48% of LOs and *interpreting results* 24.8%. The RG elements resulted in 93 classifications of the four statistical process components. The majority of elements were about analysing data (49%) and interpreting results (43%). This suggested a similar finding as in the analysis of actual module LOs that also seemed to emphasise the two later stages of the statistical process.

Participants' beliefs about the intended curricula (RQ3)

Of the 81 repertory grid elements provided by participants, 41 (50%) represented statistics-based content statements (e.g. 'regression', 'correlation', 't-test', 'report writing') rather than a LO. It may be that the participants construed their intended curriculum considering the content of the syllabus, textbooks, time allocated to different activities and assessment tasks rather than intended LOs (Hussey & Smith, 2002). The emphasis on content rather than intended LOs may also explain the higher proportion of statistical-based elements. Further, the participants' reliance on content rather than statistical reasoning was despite the fact that the participants were presented with a definition of statistical literacy, reasoning and thinking (Ben-Zvi & Garfield, 2004, p. 7) at the beginning of the interview, which was then discussed in the context of their module. On the other hand, RGT required participants to provide a list of elements within a short time and not overtly defined as LOs.

Conclusions

The interviews using RGT allowed lecturers to construct in their own words the intended curricula in their own context. The classifications into the statistical process components, whether there was a requirement for statistical reasoning/thinking and the types of LOs revealed some similarities between actual official curricula and the grid data. It may be however that the broad nature of some of these elements produced by participants might not reflect the implemented teaching. For example, 'statistical inference' may involve a number of activities and reasoning processes, which the participants did not express in these brief elements. The analysis indicated that the participants focused more on content than on LOs. This finding may however be due to the interview design, which predominantly focused on statistics. Despite some possible limitations with the research design, we consider RGT to be useful in capturing lecturers' tacit knowledge about their intended curriculum. Future studies could for example allow participants more time to prepare for the RG interview and provide richer elements for construct elicitation.

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