TEACHERS' PERCEPTIONS OF BEST PRACTICE IN STATISTICAL LITERACY EDUCATION

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This paper reports on teachers' perceptions about how to teach students' statistical literacy effectively. The interview data used in the analysis were collected from high school teachers located in 7 different schools across one Australian state as part of a 3-year longitudinal study investigating students' development of statistical literacy. The interview transcripts were examined using the software package Leximancer (Smith, 2009). This program read the text and created a concept map of the data. The resulting map supports the notion that students' engagement with statistical programs and statistical literacy activities are enhanced when there is a focus on the students: doing; using; understanding; and discussing.

The evidence is that classroom teachers' own attitudes, knowledge, and beliefs about the curriculum content they are expected to teach significantly influences their students' learning and educational outcomes (Hattie, 2009). If teachers are to influence their students' learning outcomes, Shulman (1987) has argued that effective teachers require: content knowledge; general pedagogical knowledge; curriculum knowledge; pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of education contexts; and finally knowledge of educational ends, purposes, and values. Given this, teachers' own attitudes, knowledge, and beliefs associated with statistical literacy should have a direct and indirect influence on their students' learning and educational outcomes in this domain.

Statistical literacy has been defined as the ability to interpret and evaluate critically information that contained statistical elements (Callingham & Watson, 2005; Carmichael, Callingham, Watson, & Hay, 2009; Gal, 2003). The elements comprising statistical literacy have been identified by Watson (2006) to be: sampling and data collection; graphs and data presentation; average; chance; beginning inference; and variation. This challenge of enhancing students' statistical literacy via enhancing their teachers' knowledge of statistical literacy was a core aim of the Australian *StatSmart* program. *StatSmart* was a three year project involving 17 primary and high schools in the Australian states: South Australia; Tasmania; and Victoria (Callingham & Watson, 2007).

The major educational aim of this longitudinal research has been to improve the statistical understanding of school students through the improvement of the teaching of statistics at the middle and high school levels. That is, to improve the students' ability to interpret and critically evaluate messages that contain statistical elements. To facilitate the teachers' statistical literacy the chief instigators provided the teachers in the *StatSmart* program with three resources: (1) the educational software *Tinkerplots* (Konold & Miller, 2005); (2) use of real data sets from the *CensusAtSchool* website (http://www.abs.gov.au/websitedbs/cashome.nsf/Home/Home); and (3) regular teacher workshops and information about students' development of statistical literacy. As part of the evaluation of the *StatSmart* program, teacher interviews were conducted towards the end of the intervention, with each teacher having at least 18 months experience with the program.

It is thus the aim of this paper to investigate the following research question: What did the teachers who participated in the *StatSmart* program consider to be best practice when developing their students' statistical literacy?

METHODOLOGY

Participants

In this study the participants were 12 teachers from one Australian state who were involved in the *StatSmart* program in their high school, which taught students from Grade 7 to Grade 12. Ethical approval to interview the teachers was given by the relevant University and school authority, and the teachers themselves. Towards the end of the intervention each of the

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php [© 2010 ISI/IASE]

participating teachers was asked questions that focused on their perceptions about how to effectively teach students' statistical literacy.

Analysis

The teacher interviews were tape-recorded and transcribed. These transcripts were then entered into the software package *Leximancer* (Smith, 2009) for further analysis. The Leximancer program "reads" the text and creates a map that is comprised of a set of 'concepts'. Each concept is charted and plotted in relationship to all the other relevant concepts contained within the text. Such concept mapping allows the researcher to "follow the collective thinking pattern" of the individuals who generated the text. Words that are said more frequently are shown as larger nodes on the map and it is how other ideas link to these words that is reported on the map.

Procedure

The teachers' responses were saved as one file for the analysis used in this paper and the initial *Leximancer* analysis was conducted without merging or deleting related words although the teachers' identities were taken out of the file. It would have been possible in *Leximancer* to have treated each teacher's text or group text separately, rather than as a tabulation of teachers' text, and this is a possible future recommendation associated with this research.

RESULTS

Leximancer produces a ranked list of concepts, based on a frequency count of words that are central to the text being studied, which is interpreted as a relevance percentage in the text. Because of space limitations in this paper this vocabulary table is not presented, but for illustration purposes the concept word "kids" (students) was mentioned 132 times and had a relevance in text rating of 42%, the concept word "data" was mentioned 76 times and had a relevance in text rating of 24%, and the word "grade" was mentioned 103 times and had a relevance in text rating of 33%.

Leximancer, however, goes beyond just a word count and develops a conceptual map of how the concepts are linked together in themes and provides "meaning" to the interview data in two critical ways. First, the program graphically draws how the different concepts are linked in a pathway fashion, and second, the program maps the proximity spacing between concepts. Lines indicate linked concepts on a pathway, following the logic of the interviewees' responses. The physical location and closeness of the concepts on the map suggest ideas that have linked relationships in the text and plotted on the "grid" map, such that ideas that are dissimilar are plotted further away.

In *Leximancer* this mapping of ideas and their pathways and the spacing of the words (concepts) on the map is produced mathematically, based on frequency of the words and where the words are placed by the participants in their text. If a word is mentioned more times this word node is shown as larger on the map and in a colour printout, is shown in a brighter colour, such as red. The *Leximancer* produced concept map of the teacher interview text is displayed in Figure 1. In the following section the plan is to review and describe the generated *Leximancer* concept map. Although it is possible to do this in a number of ways, for the purpose of this paper the starting point is the upper right hand corner and from here the reader is asked to work down the diagram to the centre of the map by following the branches and their nodes.

Referring to Figure 1, the upper right hand corner starts with the word node "Int" and this relates to the interview question: What is best practice in teaching statistical literacy based on your experience and involvement with the *StatSmart* program? The first and main concept identified in the teachers' responses to this question is "interesting" and this line of thinking flows down to the word "use".

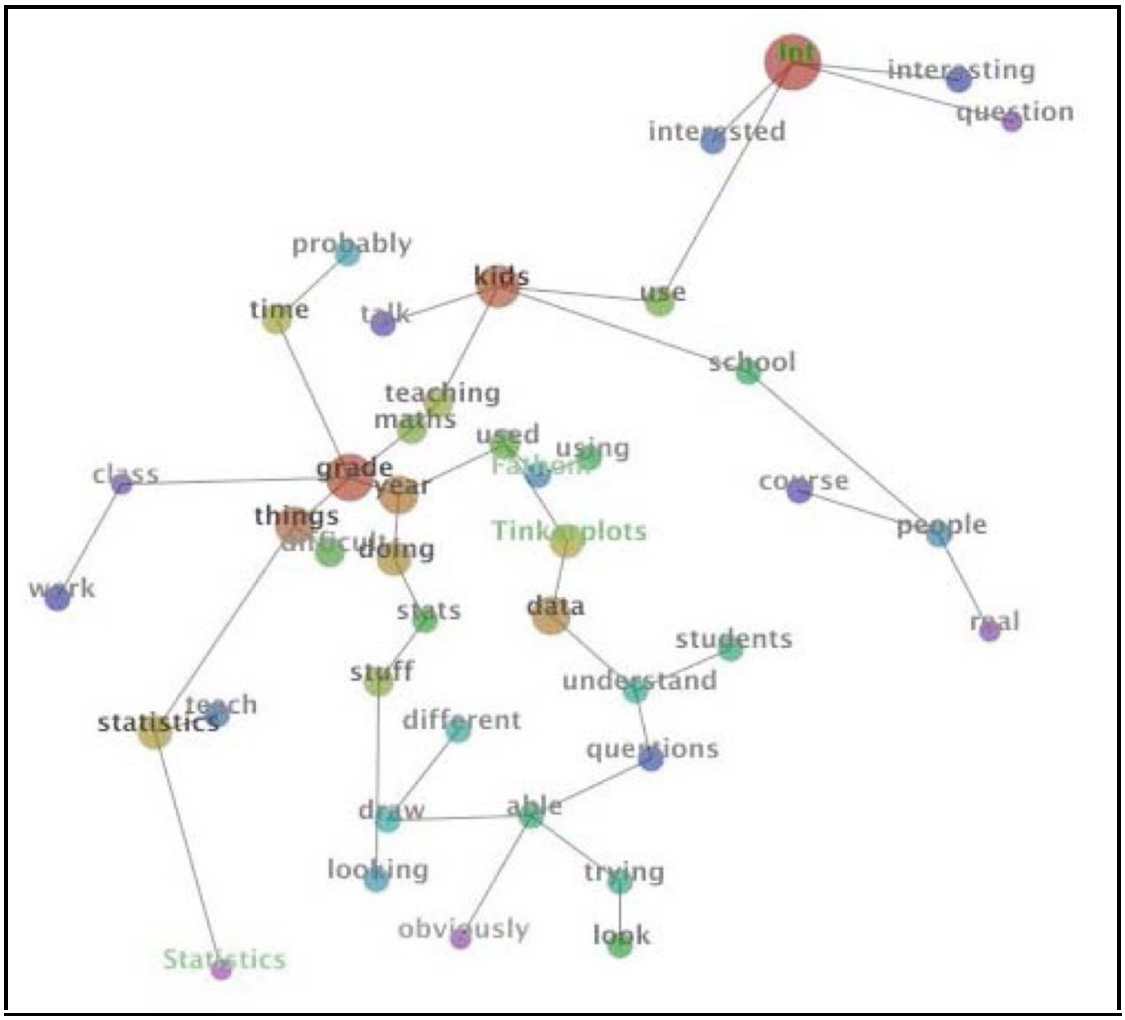

Figure 1. *Leximancer* conceptual map of teachers' interview response to teaching statistical literacy

Looking at the branches, after the teachers link the word "interesting" to the word "use, the word "use" then links to the large node "kids" (the students). This central node "kids" is linked to "talk", "use", and "school". That is, across the text responses the teachers are reporting that it is best practice if students talk about the content and the students find the activities interesting and useful. The central concept node "kids" has two major pathways and the smaller branch explores the theme of "school" and ends with the notion of making the statistical literacy "real". The second branch is the main one in the Figure 1 concept map and the central concept node is "grade" or age of the students.

There are four lines that flow out from this central "grade" node concept. The first line focuses on "data" and this line is linked to the statistical packages "Tinkerplots" and "Fathom". Linked to this are the concepts of understanding data ("understand") and questioning ("questions"). The second line from "grade" is "doing" and this concept is linked to strategies such as "looking". The "data" and the "doing" lines are clustered close to the concept word "able". This clustering implies that being "able" to do the statistical tasks is related to the skills of drawing and questioning. The third line is linked to the word "teach". This branch seems to be referring to the teaching of statistical literacy using a lecturing style and although this idea is near to the "doing" branch, it is a separate line. This suggests that the two activities may occur together, but when the teachers talk about their students "doing" statistics the teachers expand on this and see this as a much richer learning task than just lecturing. The lecturing pathway is not extensive and it is not connected to the students "doing" line.

DISCUSSION

This paper has reported teachers' interview text data using the *Leximancer* program. Although there may be debate about the value of such a "mechanical" approach to quantitative data analysis, *Leximancer* does provide an initial and even a possible confirming analysis of text data that has historically been time consuming to map and at times difficult to interpret. The map produced from the teachers' responses to implementing the *StatSmart* program supports the notion that the engagement of students in the learning is critical. The evidence for this is shown by the initial concept "interesting" and its direct relationship with the node word "use"; that is, the students become interested in statistics through usage.

The diagram map also indicated that developing students' statistical literacy is facilitated by activities that concentrate on the key concept of doing and understanding. This is consistent with calls for students to experience a variety of representations of data that allow them to "tell the story" (Watson, 2006, p. 56). Lajoie (1997) also suggested that students need to be able to manipulate data depending on the kind of analysis they choose in order to demonstrate their understanding. The pathway branch that links "Tinkerplots", to the word nodes "use", "data", and "understand" in part, illustrate her point. Taken as a whole, the findings identified from the teachers' interview text analysis supports Starkings' (1997) findings, that the effective development of students' statistical literacy is often achieved when the students are engaged in interesting and useful activities.

ACKNOWLEDGEMENTS

Thanks to Prof. Rosemary Callingham and Prof Jane Watson for their assistance in providing the data set and the advice of Dr Peter Grimbeek. The research data were collected using funds provided by the Australian Research Council grant number LP0669106.

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