ENHANCING STATISTICAL LITERACY THROUGH REAL WORLD EXAMPLES: A COLLABORATIVE STUDY

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There is a considerable and rich literature on how to develop students' statistical thinking. However, there has been less attention paid to the development of students' statistical literacy in the statistics classroom. This paper attempts to fill this gap. It describes some pedagogical strategies and rich learning activities from a collaborative research conducted at one school. The research team capitalised on each other's skills and experiences and expert roles were taken at different times. The final section draws some conclusions for teaching and further inquiry.

INTRODUCTION

The importance of statistics in everyday life and work place have led to calls for an increased attention to statistical literacy in the mathematics curriculum. Professional organisations such as the National Council of Teachers of Mathematics (2000) and The New Zealand curriculum (Ministry of Education, 2007) promote a critical perspective towards statistics. Additionally, schools are being asked to prepare students to be flexible thinkers, lifelong learners, and to manage complexities of an uncertain world (Ministry of Education, 2007). Having a good grasp of social statistics can help citizens deal with a complex array of issues and participate actively in public debates and assert their rights.

According to a number of authors (Kieran, Krainer & Shaughnessy, 2013; NCTM, 2010; Shaughnessy, 2014) historically practitioners have tended to be viewed as consumers of research by the educational research community rather than active participants in the generation of new knowledge about the teaching and learning. Groth (2007) argues that the relationship between educational research and teaching has been typically stormy because researchers are often interested in theoretical aspects and general questions whereas teachers are usually interested in solving problems related to situations that arise in the classroom on daily basis. The base of this dichotomy is that the theoretical knowledge is delivered in the university while practical knowledge is delivered in the classrooms (Anderson & Freebody, 2012). Hence, teachers have not often been involved in the design of the research, the generation of research questions, the analysis of data, or the dissemination of results. Recently researchers in mathematics education have begun to involve teachers more as key stakeholders in research in an effort to forge closer links between research and practice (Kieran et al, 2013; Shaughnessy, 2014; NCTM, 2010).

This paper describes pedagogical strategies and rich learning activities from our collaborative research (Sharma, Doyle, Shandil, &Talakia'atu., 2011) conducted at one school. The team capitalised on each other's skills and experiences and expert roles were taken at different times. The first section of the paper outlines definitions and components of statistical literacy followed by a brief description of our collaborative study. The next section describes learning activities used in our study. As part of the learning activities, students critically evaluated statistical investigations undertaken by others, consistent with the curriculum (Ministry of Education, 2007). The final section of the paper draws some conclusions and offers suggestions for teaching and further inquiry.

DEFINITIONS AND COMPONENTS OF STATISTICAL LITERACY

Gal (2004) sees statistical literacy as the need for students to be able to interpret results from studies and media reports and to be able to pose critical and reflective questions about those reports. Gal (2004) proposes a two-component model of statistical literacy: a knowledge component comprising five elements (literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions) and a dispositional component comprising two elements (beliefs and attitudes, and critical stance). Gal contends that to be statistically literate, a person needs to have developed a willingness to adopt a critical stance and a belief that it is

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legitimate to be critical of statistical messages. For Gal, statistical knowledge is contingent upon the context or setting. Watson (2006) sees statistical literacy as the "meeting point of the chance and data curriculum and the everyday world, where encounters involve unrehearsed contexts and spontaneous decision-making based on the ability to apply statistical tools, general contextual knowledge, and critical literacy skills" (p. 11). For both Gal and Watson, questioning claims made in social contexts such as media reports is fundamental to statistical literacy. Indeed, media reports can be used as motivational tools and a springboard for drawing out the big statistical concepts and processes.

From the above definitions, it is evident that statistical literacy is a complex construct that requires not only a range of skills (reading, comprehension, communication) but also higher order cognitive skills of interpretation and critical thinking. Like Gal, we believe that literacy skills are crucial for statistical literacy because statistical messages are mostly conveyed through written text. Text comprehension support is important for helping learners interpret meaning from the often unfamiliar, out-of-school contexts and writing styles different to that found in textbooks. Aspects of Gal's (2004) knowledge components were incorporated in the learning activities outlined below.

OUR COLLABORATIVE STUDY

The teaching took place in two Pasifika dominated Year-9 classrooms as part of regular mathematics lessons to suit the school schedule. The research team —researcher and three teachers—generated both professional and scientific knowledge by working closely together. As a team we aimed to understand the nature of statistical activity and to develop new ways to look at student discourse and to develop teaching strategies that offered students opportunities to discuss and debate practice. The following inter-related research questions guided our study:

1. What learning activities and tools can be used in the classroom to develop students' statistical critical thinking skills?
2. How can we develop a classroom culture where students learn to make and support statistical arguments based on data in response to a question of interest to them?

The data set consisted of video-recordings of the classroom sessions, collection of copies of all of the students' written work, audio recorded mini-interviews conducted with students during class time, and field notes. Semi-structured interviews were also conducted with a selected number of students from each class after lessons and while the design experiment was in progress. These interviews focused on students' interpretation of classroom events with a particular emphasis on the identities they were developing as consumers of statistics. Each teacher-researcher kept a logbook of specific events that took place during the data collection period. These logbook entries helped the research team identify and keep track of which strategies seem to work well for students and which ones were less successful.

LEARNING ACTIVITIES

As part of the planned activities it was expected students would need to evaluate statistical investigations or activities undertaken by others, including data collection methods, choice of measures and validity of findings (Ministry of Education, 2007). We expected students to ask critical questions such as how the data was collected, who collected the data, what was the sample size and so on.

This section describes tone learning activity trialled in our study; a music survey and an examination of statistical report. The activities were flexible in that teachers could adapt them to suit the needs of the students.

To participate successfully in the activities, students also needed familiarity with the statistical enquiry cycle (Wild & Pfannkuch, 1999), statistical measures of centre and spread, data displays and analysis, and literacy and numeracy skills. Students in our classes were of different language and statistical abilities and activities were designed to ensure students were interacting with each other in order to improve their statistical communication. Support was provided for both reading and writing in statistics. Supports included assisting with vocabulary acquisition, such as using pre-reading and further reading strategies such as shared reading and scanning techniques. Writing support included the use of writing frames, cloze activities and composing responses individually and in groups. The student-student interactions presented various demands on students' literacy

skills, as indicated in the following student quote:

> *Because usually, like in normal maths, we don't use literacy … like we use addition, subtraction but we actually need some kind of literacy for the things we do in statistics.*

Questioning was one of the key teaching strategies used in our study. We wanted both the students and the teachers posing questions that would support student learning. The teachers posed prompting and probing questions that diagnosed and extended student thinking - questions that elicited student ideas and encouraged them to explain and justify their contributions in respectful ways. Students needed to formulate and pose critical questions in ways that assisted them to evaluate statistical statements and reports. We start with an activity intended to capitalise on students' interest in music, a music survey**.**

Activity – Music Survey

The purpose of this activity was to introduce students to some critical questions that would help them evaluate surveys undertaken by otheres. The activity provided opportunities to students to express their opinions and concerns both verbally and in writing. We started by introducing the context of the activity by asking questions such as: How many of you like music? What type of music do you like the most? How much do you spend on music? We then presented the scenario below. Students could read the music survey scenario individually and make a note of any difficult words. These words were posted on the whiteboard. Students were encouraged in pairs to represent the words through interpretative drawings and labels.

Survey shows Recorded Music Appeals to Teens

A marketing research company was asked to determine how much money teenagers (age 13 – 19) spend on recorded music (cassette tapes, CDs and records). The company randomly selected 80 malls located around the country. A researcher stood in a central location in the mall and asked passers-by who appeared to be the appropriate age to fill out a questionnaire. A total of 2 050 questionnaires were completed by teenagers. On the basis of this survey, the research company reported that the average teenager in this country spends $1155 each year on recorded music.

Students answered the questions below. Having students working in small groups enabled for a discussion of their opinions.

1. Who carried out the survey? What was the purpose of the survey?
2. How was the survey done? Why do you think this method was used?
3. What are the main findings of the survey?
4. Comment on two concerns you have about the survey.

Students were encouraged to write down their response for each question. Groups then presented their concerns to the class. When we used the music survey activity, concerns raised by students about the sample selection process used in the study were:

> *They only asked passers-by in the mall. As Mr T says, this might bias the results because teenagers outside the mall were not asked.*
>
> *How did they calculate the average? Did they get rid of odd numbers [outliers]? Some teenagers spend more money than others.*
>
> *They should have done the survey at more than 80 malls if they wanted an average based on teenagers throughout the country.*

The last student quote above reinforces to us that students can struggle with thinking of the sample size in relation to the size of the country, rather than in relation to the representativeness of the sample. However, for the above scenario, theirs is a valid concern because hardly any information had been given regarding the target population.

Like the activity above, most of our classroom activities included group and whole class discussion of the data. Typically, we used a small group activity (4-5 members) in which the students worked on tasks together and then reported back to the whole class. The groups were organised to include students with a range of mathematical, statistical, and language abilities because we believed that varying insights would enhance overall understandings.

The teachers ensured that students understood and adhered to effective group problem

solving practices, including listening, writing, answering, questioning, and critically evaluating information. The teacher in the following transcript explains their expectations:

> *When working in the group, first of all each one of you has to say what your concerns are. Then I want you to come up with a group response. You should not only say bias, headline and questions, you need to clearly explain your reasons. Remember - at the end of your group discussion, everyone in the group needs to be able to explain why you chose that response. Also, anyone in the group can be asked to present to the whole class.*

During reporting back the whole group was required to stand with the reporter and share the responsibility for explaining their reasoning and responding to any questions from the class. These norms encouraged the students to work together, communicate, and be responsible for the learning of everyone in the group. The teachers took time to remind students of effective group practices (e.g., ways of agreeing and disagreeing and how to present to the class):

> *The group is not finished until everyone in the group can explain and defend their answer. When we come together as a class to share our ideas, I will simply ask any one student to report on why they agree or disagree with a particular statement.*

We found students' confidence in their ability to read and critique statistical reports grew as they worked on the activities shared in this paper.

CONCLUSION

This paper aimed to raise questions about what is required to foster statistical literacy in our students. Our findings showed that with suitable scaffolding and support students were able to interpret, critically evaluate, and communicate statistical information. We found it helpful to scaffold students' learning by providing thinking and questioning routines.

Our study was a long term teaching experiment involving a team of teachers and researchers and it suggests only a few ways to develop statistical literacy. Our research and practice was based on respectful genuine relationships and ongoing negotiations. Using activities such as those given in thispaper, these sentiments and modes of collaboration can also be encouraged in students' work with one another. More research and experimentation to explore the effectiveness of particular sequences of activities, the use of different technological tools, and the teachers' role in developing statistical literacy will be useful to inform further development in understanding of how students can be helped to develop statistical literacy.

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