Addressing Language Barriers in Multilingual Statistics Classrooms: A Collaborative Study

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It is acknowledged that there are connections between language use and mathematics in mathematics education, and the potential challenges this issue can pose have been investigated by researchers. Yet how the challenges can be overcome in statistics classrooms, where language is even more important as a medium of instruction, has received very little scrutiny. This article reports on research carried out in three New Zealand largely Pasifika dominated Year-12 classes. Findings from the teacher reflection aspect of the study indicate that teachers can struggle with how to use home language and real-life contexts to maximise learning in their classrooms. Some strategies to incorporate students' home language in their learning worked better than others. However, more research is needed to explore language issues and the barriers they might present in statistics education in greater depth.

Introduction

Multilingual classrooms are an increasing feature of schools worldwide, in part due to immigration as a response to poverty and war but also as part of efforts to maintain minority or indigenous home country languages (European Commission, 2015). In multicultural classrooms students may speak one language at home and another language at school, teachers and students may not share a common language or cultural background and some or all of the students may be learning the language of instruction as a second language. Responses to multiculturalism related to language use can vary. Planas and Setati-Phakeng (2014) describe three perspectives that impact on the development of language policies and multilingual classroom practices: language-as-problem, language-as-right, and language-as-resource. These scholars see a language-as-resource approach as increasing the learning opportunities of all learners by focusing on both mathematics and language as being connected in the teaching and learning process.

While the role of language in the teaching and learning of mathematics is now well established in the literature (Clarkson, 2007; Hoffert, 2009; Moschkovich, 2005; Planas & Civil, 2013), there have been a few research studies about language issues in learning statistics (Kaplan, Fisher, & Rogness, 2009), It is important to gain insights into how English Language Learners (ELL) learn statistics (Kazima, 2006; Lesser & Winsor, 2009, Sharma, 2014). Given the dearth of research on multilingual classrooms, this paper provides a contribution and stimulus for more debate and research in this area.

Literature Review

Within any particular language, there are many distinct registers, including everyday conversation, mathematics, statistics, and so on (Gibbons, 2008; Marin, Schleppegrell, 2011). Halliday (1974) used the term *register* to refer to the specialised method of communication used in a particular social practice. The statistics register, for example, would include words unique to statistical communication, but also specialised uses of everyday words, which take on unique meaning in statistical contexts. To succeed in a statistics classroom, students need to not only be familiar with and competent in their

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ordinary English register, so they can communicate with their classmates, but must also have fluency in what can be termed multiple mathematical registers (Kazima, 2006).

One example of confusion between the everyday and statistical English (Lesser & Winsor, 2009) involves the term independent. Since the everyday meaning of independent can be associated with separateness (e.g., independent nations), the authors conjecture that this leads students (incorrectly) to equate independence with disjoint sets (i.e., mutually exclusive) Another technology-related example provided by Lesser and Winsor is the term mode. The mode button on a calculator, for example, has nothing to do with the most frequent observation in statistical context.

It is not only the meaning of words used *within* a statistical context that can be confusing. While some terms have different meanings in everyday usage and in statistics, some are also used in mathematics in more than one way (Kaplan, Fisher & Rogness, 2009; Lesser & Winsor, 2009). A relevant example of this point is use of the word 'significant'. This term has one meaning in ordinary English, a second in mathematical English (when thinking of significant numbers), and a third meaning in statistics.

Schleppegrell (2011) claims that technicality can also be conveyed in grammatical choices in mathematical texts including long, dense noun phrases and relational and attributive phrases. A statistics example could be "the upper quartile of a normal distribution with mean 75 and standard deviation 10." Kaplan, Fisher, and Rogness (2009) considered the role of lexical ambiguities in the statistics classroom. Kaplan et al. (2009) define words that lack a core meaning as lexically ambiguous and suggest that ambiguous words such as "spread" should be avoided.

The research literature describes many language strategies that teachers can use to address some of the linguistic challenges faced when the language medium of instruction is different to the home language(s) of students in an educational setting. Plana and Civil (2013) report that teachers and students switch between languages in mathematics lessons because learners communicated their mathematical thinking more easily in their home language. Further, this switching improves mathematical dialogue in the classroom. Halai (2009) argues that to understand mathematical ideas and concepts, one has to be able to understand the instruction-language. This means that if the instruction-language is foreign to the learner then it becomes a double task - that of learning both the foreign language as well as the mathematics that is being taught, all at the same time. Halai (2009) suggests that this problem can be addressed only by allowing for movement between the languages used in the class.

Research studies by Clarkson, (2007); Mady and Garbarti (2014) provide examples of the tension between the use of home and school languages. These researchers examine the use of students' home languages, or practices such as code-switching. According to Clarkson translation is not always beneficial or reliable as it might not reflect the exact meaning. Thus switching between languages can add an extra layer of challenge to language learners, as they may find themselves working between a multitude of registers in both the medium of instruction and their home language (Mady & Garbarti, 2014; Schleppegrell, 2011). Grappling with how language is used in statistics can present challenges for any student (Kazima, 2006; Lesser & Winsor, 2009). However, to understand mathematics in an English medium classroom, ELLs may have to undergo more processing than native English speakers (Kazima, 2006; Latu, 2005; Meaney, 2006). Students must simultaneously learn ordinary English and mathematical English, and to be able to differentiate between these two types of English language use (Moschkovich, 2005; Schleppegrell, 2011).

Research Design and Data Collection Methods

To conceptualize our study, we drew on design-based research theory (Cobb & McClain, 2004). Design research is a cyclic process with action and critical reflection taking place in turn (Cobb & McClain, 2004; Nilsson, 2013). There are benefits for both teachers and researchers when undertaking a design research partnership: the research plan can be flexible and adaptable to unforeseen effects or constraints (Nilsson, 2013). Further, all participants are equal partners in the research process with no hierarchy existing between researchers and practitioners (Hipkins, 2014). The following inter-related research questions guided our study:

1. What language resources and strategies appear to enhance the statistical understanding of Pasifika students?
2. How do groups of Pasifika students negotiate communication in small group settings?

The study itself involved cycles of three phases: a preparation and design phase; a teaching experiment phase; and a retrospective analysis phase. Teachers were involved in the whole research process (posing questions, collecting data, drawing conclusions, writing reports and dissemination of findings (Sharma, 2017).

The preparation phase began with a discussion of research findings on language challenges and language-as-resource pedagogical strategies for ELL. The research team proposed a sequence of statistical ideas, language skills, and attitudes that they anticipated students would construct as they participated in teaching and learning activities.

The teaching took place as part of regular classroom statistics teaching in three largely Pasifika student dominated Year-12 classes. As part of the learning activities, students carried out investigations of existing data sets using the statistical inquiry cycle method During the teaching experiment, audio and video recordings of group discussions were made. Each teacher-researcher also kept a logbook of specific events that took place during the data collection period. Logbook entries helped teachers identify and keep track of which strategies seem to work well for students and which ones were less successful. The three teachers and researcher performed a retrospective analysis together after each lesson to reflect on and refine the lesson plans while the teaching experiment was in progress. In addition, the team analysed the whole unit on completion of the teaching experiment cycle.

Findings

A thematic analysis was used to generate emerging themes (Braun & Clarke, 2006) with the researcher examining the reflective summaries for topics which were found to re-occur in the data. Themes were then coded in the summaries. As data were analysed six key themes emerged.

Integrating statistical language and content

All teachers mentioned students' difficulties with reading, speaking and writing in English. This affected their ability to engage in written work. According to Teacher A (TA), this could be due to students not using English language at home.

> Students don't want to write down…they are struggling to speak, read and write. They remain silent even though they miss key phrases. They speak their own language at home .... even when doing homework, they may not speak English. (TA)

In contrast Teacher C's (TC) reflection suggests that sometimes mathematics teachers might not have the skills to teach the written component of statistics.

> Mathematics teachers find it hard when you got to do scaffolding. We are not natural teachers of writing. It is okay in mathematics and then as math teacher we are not good at a particular way of writing and helping with statistics requires a different way of writing. (TC).

Although TC expressed concerns about integrating writing in statistics, it was clear that the teachers were supporting their students in their writing by integrating language strategies and statistics content in their lessons, an important component in statistics lessons and, in particular, statistical projects. All reported that they had to write and draw a lot on the whiteboard. They used class notes so the students could follow what was being discussed. Writing the key terms helped students see them and connect them to the spoken word.

All teachers used techniques to make sure all understood the instructions. Teacher B (TB) gave explanations and instructions in clear and simple language and then asked a student to repeat the explanation so.

> I try to give instructions step-by-step before asking students to do independent, pair, or group work. Then I ask one of the boys to repeat the instructions aloud for the rest of the class to make sure all have understood what is required (TB).

In her whole class sessions TA slowed down her speaking pace a bit while TC reported modifying the linguistic complexity of his speech by using shorter sentences and re-phrasing questions. As well as modifying speech, TA also wrote notes and questions on a mini white board she used during her small group interactions. Both TA and TC also provided a writing frame and cloze activities to help students analyze data and draw conclusions. However, despite assistance all three teachers found students had difficulty writing appropriate questions related to their statistical work, as TA suggests:

> I found students struggling to write good comparison and relationship questions. I put a summary, comparison and a relationship question on the board and asked them to critique them using "What makes a good question" criteria. I spent one whole session on posing statistical questions (TA).

Using collaborative learning

Forms of collaborative learning were used by the three teachers. Students were asked to form groups to discuss the ideas and questions they might have relating to the statistical inquiry cycle. Students felt more comfortable in this safe learning environment, according to TC:

> Students are often not eager to share their ideas in front of the whole class. It is not productive to ask the boys to give answers to the entire class. They may not feel confident with their level of English and content and going public may make them more uncomfortable (TC).

This strategy also freed up the teacher to provide more informal explanations of terminology used, as can be seen below:

> "Miss what does Shape refer to?" One would usually associate the word shape with something that has an external boundary. It was quite helpful to discuss this with students (the fact that we can refer to the box plot and the dot plot) when we talk about the shape of the data. It allowed me as a teacher to elaborate even more in group situations. Words can have different meanings in mathematics and statistics. We spoke about other types of shapes of data distributions. (TA).

However, all teachers mentioned that they had to be careful how they grouped the students. Sometimes the students did not engage in productive talk in their group, so a variety of grouping methods was used. Grouping could include students access to language proficiency.

Home language

In this study, students were supported by teachers and peers to use their home language, English and mathematical/statistical English. All teachers identified that students' first language(s) already served as a resource for thinking and communication, as students developed their proficiencies in the language of instruction and learn statistics. Teachers too were already mixing languages while learning was taking place as noted by Teacher C: *Even teachers sometimes code switch although they don't realize it to gain student attention or to build positive relationships with students.*

However, TA commented, using a different language was not possible for her. Sometimes she was not sure what the students were talking about. As she did not speak their home language. Further, not all students took advantage of being able to talk more informally in their home language, even when they knew that the initiative was fully supported;

Using hands-on activities

Providing non-linguistic cues such as visual diagrams, drawings and gestures can make more complex language accessible for all learners. All teachers in the study seemed intuitively aware of this. TA used demonstrations, pictures, gestures and actions to aid understanding. While TA and TB used a hands-on sequencing activity to explore student prior knowledge regarding PPDAC. This activity proved to be extremely useful as TB reflects:

> This activity was a sequencing pre-test to find out what students understood about the PPDAC cycle. They needed to organise the student exemplar into the correct order. It was interesting to note that the students did not need prompts to find where the Problem and the Data should be placed. They had a difficult time separating out the plan and the analysis. Several of the groups were not sure between the two and this gives me a starting point for where they need some support.……. This task was useful because I identified what students remembered about the PPDAC cycle through discussion. I was able to see which groups of students understood the statistical enquiry cycle because the puzzle was complete (TB)

Using real life contexts

The teachers in this study were also aware of the use of making connections to the experiences and cultures of Pasifika students. Teacher A stated: *When I look back should have done investigation outside the classroom. Students need to pose questions on something that is relevant to them or their community. May be involve the parents as well.* Also, TB commented on the importance of building contextual knowledge in statistics.

> It is important they understand what population and variables they can make links to. Some of them have never seen a kiwi, they don't understand the context. Half way I realised that some of them were interpreting kiwi as kiwi people. They related the data to people. Next time I will spend more time on context, may be show them a video clip about kiwi population. (TB)

One further theme which emerged from the teacher participants suggest strategies is not so frequently found in the literature concerning working with Year 12 students: Using games and matching activities. TA and TB mentioned using card games to help Pasifika students develop their statistical vocabulary. TB used a fun game called Forbidden Words to start or end a lesson. The idea of the game was for one player to try and describe a statistical term or phrase without using certain forbidden words. The other players have to try and guess the word. For example, Fila picks out word card - 'standard deviation'. He then has to describe the phrase without using the word meaning - variance, square root and sigma. Other students try to guess the word.

TA used a matching activity to help develop students' statistical vocabulary. Students were provided with sets of word and description cards and asked to work in pairs and sort statistical terms with their descriptions. For example, the term "inference" was matched with its description "the process of drawing conclusions about population parameters based on a sample from the population". Once an agreement was reached, they could discuss their answers with another pair of students.

Discussion

It is important to have daily routines of writing, reading and speaking about statistics content. All the teachers reported that writing down the key terms helped students see them and connect them to the spoken word. This use of writing on the board to aid the language learning and comprehension of the students concurs with the findings of Meaney and Kirsten (2009) who claim that mathematical texts use language and diagrams in ways slightly different from those used in other subjects. Part of the learning for students and teachers may involve learning the common ways of presenting written materials including diagrams such as graphs.

What may seem normal speaking pace to a native speaker of any language may seem too fast for comprehension to a language learner. TC reported modifying the linguistic complexity of his speech at times by using shorter sentences. This finding concurs with the claim made by Hoffert (2009), who stated that when teaching ELLs teachers need to use short, simple sentences and avoid using slang/colloquialism.

Teamwork allowed the students to collaborate in their learning and ties in with the work of Brown, Cady, and Taylor (2009) and Winsor (2007) who explain that when language learners are able to work alongside a partner, they are given the opportunity for interaction and support, enhancing their learning. Goldenberg (2008) reported that collaboration can afford language learners the chance to ask questions and make mistakes in a safe setting, where they can receive direct and immediate feedback. This is especially true when language learners are partnered with a peer who has a higher degree of language proficiency in the language which is the medium of instruction.

While research shows that many teachers believe using home language is detrimental to learning (Mady & Garbarti, 2014; Planas & Setati-Phakeng, 2014; Winsor, 2007), this was not the case for the three participants who could see the educational value of learners being able to using their home language(s) in the classroom. What did prove difficult was the changed role of the teacher who cannot understand the home language.

Providing non-linguistic cues such as visual diagrams, drawings, and gestures can make more complex language accessible for all learners and the teachers seemed to be intuitively aware of this. The teachers used strategies that supported students visually and was helpful in scaffolding learning for students who may not have the language skills to match their statistical abilities. The findings are consistent with the studies conducted by Nguyen and Cortes (2013). Nguyen and Cortes claim that visual aids, such as diagrams and posters can enable students who may not have the ability to pose their questions in English, or who do not have the confidence to approach their teachers, to find answers.

The teachers in this study were aware of making connections to the experiences and cultures of Pasifika students. Teacher A's response suggests the importance of learning activities that incorporate students' language, culture and community rather than reflect beliefs that these characteristics are limitations. According to Hoffert (2009) using the contexts provided by ELLs can help provide opportunities for students to use contexts relevant to their communities during statistical investigations. This does not only mean that ELLs will understand the contexts used, but also will indicate to these students that their cultures and the resources they bring with them are valid and valued (Planas & Civil, 2013).

The emphasis on community in the cultures of many English language learners might be developed into a resource-rich classroom learning community in which real-life contexts for statistics applications can naturally and readily emerge.

Students, when carrying out statistical investigations focussed on real-life contexts, can often get side tracked by irrelevant details while ignoring relevant information. For example, some students in TB's class interpreted kiwi birds as kiwi people. The findings concur with the findings of Brown et al. (2009), and Sharma (2014). When asked to define the word 'sample', a number of the Fijian secondary school students in Sharma's study based their ideas on their everyday experiences, such as free samples of consumer goods and samples of blood in medical investigations.

Limitations and Implications for Practice and Research

The number of participants in the study is small, thus there are limitations on the generalizability of results. It was not possible to isolate whether language strategies used were because of age, gender or prior experience. A study with more participants might well achieve these types of results which would then have implications for constructing support to change teacher practices. Secondly, it would be valuable to know what the students thought about strategies used by the teachers. Future interviews with students will help explore their thinking regarding the language use of teachers in the statistics lessons to support student learning.

The study shows that dealing with multiple languages in statistics classrooms is challenging for teachers. While several, albeit small, studies in New Zealand have indicated that despite the existence of Ministry of Education documents specific to English language learners, teachers have limited awareness of issues relating to bilingualism and strategies to support language learners in the classroom, the teachers in the present study demonstrated a range of specific strategies consistent with research-based effective language learning practice. Whether this was by virtue of prior learning in teacher education or professional development, or by experience in the collaborative setting cannot be determined here, but this could be an area for future investigation.

Due to the internationalization and globalization of mathematics education there has been a growing interest in language and cultural issues in multilingual settings. Hence, this research will be of interest to the international community because it involves looking at issues that are relevant for schools in English speaking nations worldwide. Teachers need to re-evaluate their teaching methods, especially if part of their population is learning English as a second language.

Finally, this study did not intentionally look at ways in which features of Pasifika languages can help re-enforce concepts of statistics. For example, Lesser and Winsor (2009) noted that in Malay the expression for the mean is "mama rata", which translates roughly as "same level". Hence the Malay language invokes the "levelling" conceptual interpretation of the mean. The authors add that similar examples might be identified through cognates in Spanish This idea could be the focus of future research.

It is hoped that the findings reported in this paper will generate more interest in language challenges and strategies in statistics education and collaborative research where teachers are regarded as key stakeholders in all aspects of the research process. Teachers, curriculum developers, and researchers need to continue to work together to find ways to help all students develop statistical literacy.

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