SECONDARY PRE-SERVICE TEACHERS' EXPERIENCES OF INTEGRATING STATISTICAL INVESTIGATIONS IN THEIR CURRICULUM AREAS

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When teaching statistics teachers are encouraged to use real-life and student-relevant context to motivate and engage students. Linking statistics to other curriculum areas can provide that context, giving links between the world around us and the context-specific learning of statistics. There is considerable and rich literature on using meaningful contexts when teaching statistics. However, less attention has been paid to the development of students' statistical thinking across curriculum areas. This paper focuses on pre-service secondary teachers' views on integrating statistical investigations in their curriculum areas. As part of design-based study, pre-service teachers were required to explore the use of statistical inquiry cycle in their learning area. They planned, taught, and reflected on the processes of conducting a statistical investigation in their learning area. Teacher reflections indicate that while teachers were positive about integrating, they also identified some challenges.

BACKGROUND

Statistics is omnipresent in our everyday life situations. It straddles several disciplines (sports, economics and sciences) because of its wide range of applicability. Having a good grasp of statistics can help citizens deal with a complex array of issues and participate actively in public debates and assert their rights. In recognition of the importance of statistics in both school and out of school settings, there has been a movement in many countries to include statistics at every level in the mathematics curricula. In New Zealand (Ministry of Education, 2007) these developments are reflected in official documents and materials produced for teachers. Statistics is one of the three sub-strands in the curriculum document and seen as critical in the learning of mathematics and development of key competencies.

When teaching mathematics and statistics teachers are encouraged to use real-life and student-relevant context to motivate and engage students (Usiskin, 2015; Ward-Penny, 2011; Watson, 2006). Linking statistics to other curriculum areas can provide that context, giving links between the world around us and the context-specific learning of statistics. Curriculum integration is not a new idea. In 1981, Turner (1981) wrote an article in *Teaching Statistics* "Statistics across curriculum." Burrill et al. (1992) wrote a chapter on "Data analysis and statistics across the curriculum" in a book published by the National Council of Teachers of Mathematics. These articles intended to show that there were examples of data analysis and statistics in a large variety of subjects taught in school. In a medical context, Aggarwal (2018, p. 49) stated "The thinking about medicine and statistics being mutually exclusionary is misplaced. In fact, the two sciences have a close relationship." English and Watson (2016) examined a Year 5 unit of work that used the data collection and analysis cycle within a sustainability context. At the end of the unit, students did demonstrate the core understandings the authors were trying to achieve, including distinguishing between sample and population, appreciating the variation that occurs in different random samples, and making evidence-based decisions.

While research into pre-service teachers' perceptions of statistics generally suggests a positive attitude towards studying the subject, some studies confirm that pre-service mathematics teachers tend to see statistics as difficult (Leavy & Hourigan 2014; Watson, 2006). Leavy and Hourigan (2014) study with a small sample of Irish pre-service mathematics teachers noted that pre-service teachers saw statistics differently from mathematics. In addition to this, the Leavy and Hourigan (2014) findings also confirm that pre-service teachers tend to see statistics as always embedded in contexts that made it interesting to study. The purpose of this exploratory study was to investigate how pre-service use the statistical inquiry cycle in other curriculum areas and address what are secondary school pre-service views and experiences of integrating statistics across curriculum areas?

RESEARCH DESIGN

This study drew on design-based research theory (Cobb & McClain, 2004). Design research is a cyclic process with action and critical reflection taking place in turn. There are benefits for both teachers and researcher when undertaking a design research partnership: the research plan can be

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flexible and adaptable to unforeseen effects or constraints (Kieran, Krainer, & Shaughnessy, 2013). The study itself involved cycles of three phases: a preparation and design phase, a teaching experiment phase, and a retrospective analysis phase.

Nine second-year secondary pre-service teachers participated in the study during the fourth semester of their degree programme. Participants had completed some curriculum and education papers (three semesters) and their first teaching practice requirement, at an intermediate level, (in New Zealand the intermediate school system is similar to middle school, meaning in-between high school and junior school. The age group of the students in year 7/8 tend to be 10-12 years old) and were completing mathematics education as a compulsory area of study. There were five females and four males in this cohort, comprised of four PE teachers, three social science teachers and two English Language teachers. As part of this research, teachers were involved in the normal tutorial activities as planned by me. Following three statistics tutorials, the pre-service teachers planned, taught and reflected on two lessons. Pre-service teachers worked in an intermediate school with 2-3 children for two lessons. Each lesson was about 50 minutes. The process around the design and teaching of these lessons involved two phases.

Phase 1: This phase involved the research and preparation of a lesson sequence of two lessons. Each pre-service teacher researched and explored using research literature, curriculum documents and other resources provided by me. I acted as a mentor and supported pre-service teachers in using the research outcomes and recommendations to inform the design of a detailed lesson plan for use in an intermediate classroom. The lesson format adhered to guidelines put forward by the paper coordinator and incorporated specific reference to steps of the lesson (learning activities and key questions), student activities, expected student responses, teacher response to student activity/response, and goals and methods of evaluation. Phase 2: The implementation stage involved the pre-service teachers teaching the lesson in a year 7/8. Subsequently, the original lesson design was modified in line with their observations to improve the learning outcomes for children. The second implementation stage involved teaching the revised lesson with the same students and reflecting upon observations.

FINDINGS AND DISCUSSION

Data was gathered through teacher reflections and a thematic approach was used to analyse data. The discussion will be supported by the use of the participants' voice through direct quotes and relevant literature. Participants are represented using number codes 1- 9.

Appreciation of integrated curriculum

The process of teaching statistics using integrated curriculum helped participants understand that subjects often cross over and skills learnt in one area can be used in another. Participant 4, a male PE teacher reflected: "For my lessons, the context was reaction speeds as it related to body responses which is taught under health and P.E. in the curriculum. Students applied statistical process such as collecting data in PE." Participant 9, another male PE teacher stated: "I saw that stats are always in sport as most decisions are made based off whether or not you think you'll be able to complete a certain skill set. For example, the students did their investigation on what distance is the most accurate to shoot from to score in basketball so they have a better chance of scoring."

According to some participants, an integrated curriculum made learning relevant for students as they could make connections between the content being taught and their own lives. Learning became more enjoyable for the student; therefore, the students were more engaged. Participant 4, a male PE teacher explained: "I felt that my teaching helped to support students carrying out an investigation as I was able to contextualise the purpose and process of statistical enquiry so that students could connect with the learning in a meaningful way." Three participants also saw connections in the New Zealand Curriculum. They were able to see that most standards require the student to analyse different types and sets of data to achieve National Certificate Educational Assessment (NCEA) level 1(NCEA levels are the achievement levels for students to move to the next level of higher education).

Confidence integrating curriculum areas

Although initially, participants struggled to see how they could integrate their major curriculum areas and statistics in a way that used the statistical enquiry cycle, further reading and discussions gave them more confidence as stated by Participant 7, a female social sciences teacher stated: "Initially, I found making connections between my curriculum area at the level required for the

lesson and statistics challenging as I was not confident in teaching statistics and the PPDAC cycle. As I researched and found resources that could support a mathematics lesson with the context of social studies, I became more confident."

Participant 6, another female social sciences teacher originally wanted to do some form of an experiment that could very easily link in with the "movement concepts and motor skills" of PE achievement objectives but was worried the experiment would take too much time and students will not be able to focus on other aspects of the cycle. Further reading made her realise that a PE-based lesson did not always have to mean a movement-based lesson. This realisation helped her decide to find a data set that related to a physical setting, was recent, up to date and had plenty of variables that her students could explore.

Challenges

The challenges identified in the reflections related to teacher content knowledge, student prior knowledge and timeframe for completing the lessons. For example, Participant 8, an English female teacher was surprised to find how much statistics she had forgotten since leaving high school. She had to take extra time to reteach herself and ask peers for clarifications. She specifically had to reaffirm her content knowledge regarding graphing. She was unsure of which graphs to use for certain questions and types of data. However, she found the process of re-teaching herself rewarding. Participant 9, a male PE teacher also had concerns about her content knowledge. She stated: "Personally as an English Literature major, I often find myself struggling in the areas of mathematics. If I could grasp a better understanding of statistics and the process of gathering, sorting, analyzing and displaying data, I can relay this knowledge in the classroom. "

Student lack of prior knowledge and understandings regarding the statistical enquiry cycle was challenging for some participants. Participant 3, a female English language teacher reflected: As the statistical inquiry cycle and statistics was very unfamiliar to the students it meant that I had to spend more time with them." Participant 5 found that students needed extended amounts of time to create a statistical question for investigating basketball shots. While students could pose mathematical questions such as "how many shots did...get?" they had difficulty posing summary questions for the given data set. Four of the nine participants found it difficult to complete the lessons in the given time frame as stated by Participant 3: "I learnt during this process that it is difficult to conduct a lesson under 2 hours, especially when the students do not hold prior knowledge towards the topic." Participant 7, a female social sciences teacher stated that if she was to conduct a similar lesson or investigation in the future, she would highly consider the timeframe and allow herself more time to teach the statistical inquiry cycle and how this could be linked to her subject area.

Contextualizing instruction across the curriculum can reinforce meaningful engagement in authentic learning activities, as stated by some participants in this study. This is also linked to using statistics through a realistic context which can also be engaging for the learners as they can make the connection between what they are learning into what is happening and relevant in real life (Perger, 2010; Neill, 2012). However, teachers can encounter difficulty integrating learning areas when they do not understand statistical concepts (Chick & Pierce, 2008; Watson, 2006). For example, the data analysis phase of statistical investigation created challenges for participants in this study.

Participant 5's (a male PE teacher) reflection regarding students needing an extended amount of time to pose statistical questions based on data is consistent with claims made by Arnold and Pfannkuch (2018). These authors state that while students can pose comparison questions, they experience difficulty posing summary questions. The authors suggest that students might need clarity around the purpose of questions at each phase of the statistical inquiry cycle. Overall, teacher reflections indicate that curriculum integration supported the meaningful exploration of statistical concepts situated within a real-world situation. The opportunity to relate statistics to their curriculum areas helped teachers become aware of some of the advantages of curriculum integration. The majority of teachers could also see that it was sometimes difficult to conduct statistical investigations.

CONCLUSION

There are several limitations in this exploratory study. Firstly, the number of participants in the study is small, with limits on the generalizability of findings. A study with more participants might well achieve these types of results which would then have implications for constructing support to change teacher practices. A second limitation relates to getting student voice on the lessons taught by

the teachers. While this paper only discussed data sought from the pre-service teachers, it would be valuable to know what students thought about curriculum integration. While several, albeit small, studies internationally have indicated that despite the emphasis in statistics and probability, teachers have limited awareness of issues relating to this strand. The pre-service teachers in the present study used a range of specific strategies consistent with research-based effective learning practice. Whether this was under prior learning, or my experience in the collaborative setting cannot be determined here, but this could be an area for future investigation. Teacher education programmes can integrate curriculum integration philosophies, theories and methodologies in the initial and continuous professional development. Such initiatives will help pre-service teachers become familiar with the pros and cons of curriculum integration as well as teaching theories and teaching techniques.

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