2010, Vol. 12.1, 50–64 *Mathematics Teacher Education and Development*

Significant Statistics: Viewed with a Contextual Lens

Sandi Tait-McCutcheon
Victoria University of Wellington

Te Whare Wananga o te Upoko o te Ika a Maui

This paper examines the pedagogical and organisational changes three lead teachers made to their statistics teaching and learning programs. The lead teachers posed the research question: What would the effect of contextually integrating statistical investigations and literacies into other curriculum areas be on student achievement? By finding the significance of statistics nested within mathematics and other curriculum learning areas, the teachers increased their own value of statistical content and contexts and this impacted positively on the statistical achievement outcomes of their students.

During 2006 and 2007 a group of 25 lead teachers from nine schools in New Zealand formed a statistics professional development cluster. This cluster group undertook a professional development project with the broad aim of engaging lead teachers in effective action research to raise student achievement in statistics. The specific aims of the project were to:

1. develop lead teachers' content and pedagogical knowledge of statistics;
2. work alongside lead teachers to explore teaching practices that have the potential to improve student achievement; and
3. build knowledge about teaching and learning processes as they relate to statistics.

This initiative was a joint project between the Achievement Porirua Whakatutukitanga Porirua Trust Board and Victoria University of Wellington College of Education and was funded by the Ministry of Education. A representative from Achievement Porirua and four principals from the schools involved carried out management of the project. The author of this paper developed and facilitated the professional development.

The inside nesting of this professional development and existing knowledge within the teachers' context of practice was the foundation for effective implementation (Higgins, 2002, 2004). This professional development was not a generic 'one size fits all' model. It focused on these teachers, at this school, with these students, at this time, and was contextualised within individual teacher's practice settings. As Clarke (1994, p. 37) suggested "professional development programmes are more likely to achieve significant change in classroom practice if they are seen by teachers as being responsive to their needs". The professional development was customised to meet the needs of individuals and schools and ensured equitable opportunities for changes in professional knowledge that impacted positively on classroom practice. McEntee, Appleby, Dowd, Grant, Hole, Silva, and Check (2003, p. 55) described this as getting "to the heart of our practice, the place that pumps the lifeblood into our teaching, where we reflect, gain insight, and change what we do with our students".

The School Statistics Curriculum review (Begg, Pfannkuck, Camden, Hughes, Noble, & Wild, 2004) acknowledged that there had been no research into the teaching of statistics at the primary school level in New Zealand and that this was an area that needed to be researched. This paper focuses on the research undertaken by three lead teachers from Ocean School, one of the cluster schools within the project. Ocean School had an existing culture that encouraged and supported school-wide initiatives. The Principal was seen as being instrumental to the creation and sustaining of a professional learning community through building positive relationships of mutual respect and consideration arising through shared visions and real learning opportunities. The school community believed that teachers needed shared opportunities to examine the impact of their teaching on student achievement, and to make pedagogical changes for all students.

Theoretical Frame

The theoretical frame for this paper comprises three components– curriculum integration, professional development, and social constructivism. It was important to bring these three components to the project as we wanted to address student learning, teacher learning, and the design of the statistics curriculum.

Curriculum Integration

An integrated curriculum has the potential to reflect holistically the realities of students' experiences outside schools by providing reactions to issues that may be more relevant and motivating to students, and thus effectively engage and connect students with their schooling in a more organic way (Beane, 1995, 1997; Venville, Wallace, & Rennie, 2004; Rennie, Sheffield, Venville, & Wallace, 2005; Wallace, Sheffield, Rennie, & Venville, 2007). Curriculum integration may also allow for the application rather than accumulation of knowledge (Beane, 1997), and having the opportunity to utilize knowledge and skills from several disciplines may offer increased opportunities for making the curriculum more relevant (Loepp, 1999). In 1997, Beane moved beyond the integrated approach to an integrative approach in which on-going themes were drawn from life as it was being lived and experienced. Learning was related to questions and concerns that had personal and social significance, promoting critical inquiry into, and social action in, real life issues.

Connections must continually be made between mathematics and other curriculum with the aim being to provide an additional lens to make sense of what one is studying (Begg, 2002). Statistics should be taught (but not absorbed) as a respectable subject within the curriculum of mathematics. Opportunities should be taken to contextualise statistical knowledge into other curricula areas, ensuring that the uniqueness of statistics and how it should be taught is upheld

(Begg et al., 2004; Gattuso & Pannone, 2002; Moore, 2002). The skills-based statistical knowledge learned during the mathematics lessons should be intentionally and contextually put to work within other curricula areas (Beane, 1995).

For an integrated curriculum to be successfully implemented teachers must first shift their belief system from one that is primarily didactic in nature to one that is founded in constructivism (Loepp, 1999). Such a move from traditional to integrative pedagogies will require a paradigm shift from teachers in their thinking about the teaching and learning of statistics from "doing the same things differently to doing something different" (Beane, 1995, p.619).

Professional Development

Two dispositions toward professional development and facilitation were introduced by Higgins (2005) in her pedagogy of facilitation research. Higgins outlined how the orientation of a facilitator's actions (design adherence or contextual responsiveness) impacted on teachers' new learning and mathematical practice. Design adherence assumes that teachers get help or guidance from a handbook or their literal knowledge of materials or activities. The facilitator's emphasis is on classroom activity that follows the guidelines of a teacher manual. In contrast the orientation of contextually responsive facilitation has been described as a framework of ideas through which teachers are able to internalize the changes to their practice and sustain the program in terms of the context within which they work. The facilitator emphasises student learning through attention to structural elements of a program (Higgins & Tait-McCutcheon, 2006).

Social Constructivism

The social constructivist (Vygotsky, 1978) model of teaching forms the theoretical framework that focuses on the continual reconstruction of knowledge through shaping ideas and meanings rather than behaviours and procedures (Tait-McCutcheon & Sherley, 2006). Learning is seen as a social construct, and meaningful learning occurs when individuals engage in social activity. Learning is contextualised within the students' realm of experiences, and the needs of each individual are met in a setting that is both socially and culturally appropriate.

Knowledge residing within the culture is greater than the sum of its parts (Cobb, 1994; Simon, 1995). The enculturation in this co-operative environment is both on how the child socially reconstructs knowledge and how the teacher manages the environment so as to facilitate cultural renewal. The teacher's role is described as:

> Mediating between students' personal meanings and culturally established mathematical meanings from wider society. From this point of view, one of the teacher's primary responsibilities when negotiating mathematical meanings and culturally established mathematical meaning with students is to

> appropriate their actions into this wider system of mathematical processes. (Cobb, 1994, p.15)

This primarily epistemological theory was advanced by von Glasersfeld (1990) who advocated that students, through self-organisation, individually constructed their own mathematical knowledge. In describing the essential tenets of constructivism, von Glasersfeld (1990, P. 22) asserted that "knowledge is actively built up by the cognising subject" and that the function of cognition is adaptive tending towards fit or viability (Jaworski, 1994). Confusions are thought through and existing understandings are adapted, modified or altered so as to fit comfortably with the new schema (Cobb, 1994). Simon (1995) explained that:

> We construct our knowledge of our world from our perceptions and experiences, which are themselves mediated through our previous knowledge. Learning is the process by which human beings adapt to their experiential world. (p.115)

The participating lead teachers had a strong social constructivist perspective toward learning. They believed that children learned best when they were provided with opportunities to work in groups, to experience the learning for themselves, and to individually and collectively set their learning goals. The lead teachers were aware of the need to continually reflect on their own beliefs and practices and to seek to improve.

Research Question

The three lead teachers from Ocean School developed the following research question: what would the effect of contextually integrating statistical investigations and literacies into other curriculum areas be on student achievement? For the purpose of this research, contextual is taken to mean – within a note-worthy context (contextualised teaching and learning opportunities within the school plan, curriculum areas and relevant contexts, including and beyond mathematics) and in response to students' interests.

There were two components of this research. The first was to change the planning of statistics delivery from a block teaching statistics only approach to a nested curriculum-wide contextualised approach. The second concerned an overall change in the approach to statistics pedagogies where greater emphasis was placed on analysis and interpretation than on design and presentation. As Cobb and Moore (1997, p. 816) contend, "if you place design before data analysis, it is harder for students to understand why design matters".

Method

Participants

Teachers. Three teachers from Ocean School participated in the first two years of the professional development program. The characteristics of the teachers are shown in Table 1.

Table 1
Teacher demographic data

	Years of teaching	Year level taught	Years teaching at this level	Curriculum responsibilities
Teacher A	3	Year 3/4	2	ICT and Music
Teacher B	20+	Year 5/6	11	Mathematics
Teacher C	5	Year 5/6	2	Literacy

Students. During 2006 56 (Year 4-6) students from the lead teachers' classes were involved in this research. In 2007 the initiative became school wide and 211 Year 4-8 students were involved. The year levels of the 2006 and 2007 students from Ocean School are shown in Table Two.

Table 2
Student year level data 2006 and 2007

	2006 (n=56)	2007 (n=211)
Year 4	10	52
Year 5	18	46
Year 6	28	45
Year 7	NA	36
Year 8	NA	32

Professional Development and Learning Program

The professional development and learning program during 2006 and 2007 consisted of four full day cluster workshops (one per school term) and 4 days of in-class support for each school. The focus for both the workshops and in-class support was on statistical literacies being developed through:

- statistical reasoning and making sense of the data, reading the data, reading between the data, and reading beyond the data (Sorto, 2006);
- statistical investigations explored in different ways rather than different investigations being explored the same way (Beane, 1995);
- statistical thinking and a shift from skill based deterministic thinking to searching for the story in the data (Woodward & Pfannkuch, 2007); and
- data analysis comprising data generation, exploratory data analysis, and statistical inferences (Cobb & Moore, 1997).

Classroom Teaching Approach

The teachers contextualised their statistics teaching and learning programmes by looking for purposeful opportunities across all curriculum areas within their long-term plans, by increasing the use of relevant and personally meaningful questions and experiences, and by looking for social actions from data and consequences from data gathering. Each teacher reviewed their long-term plan at the beginning of the school year and looked for opportunities within other curriculum subjects where statistics teaching and learning would naturally fit. This way statistics could be taught as a skill during mathematics time and employed as a tool within other curriculum subjects. Teacher A gave her class a diagnostic assessment to ascertain their current knowledge about a soon to be studied social studies topic. The results of this diagnostic were graphed and presented to the class. From this data the students were able to identify their current knowledge and more capable others, and to set class and individual next learning steps.

Teacher B asked her class to hypothesis about the athletic abilities of the students in their class. The assumptions included statements such as "tall people can jump higher", "boys are better at throwing the shot-put than girls" and "older students will always do better than younger students". As the students in this class trained for their school athletics competition data were gathered to test, challenge, and at times confirm their assumptions. The investigation was then extended by comparing their results with their parents and with data from the 2008 Beijing Summer Olympics Games.

Within the health and physical education curriculum Teacher C's class undertook investigations of the types of food they had in their lunch boxes. These findings were analysed and compared to the lunch boxes of younger students and their parents. This led to the students researching the healthiness of Ocean Schools' lunches program, and changes being made to the lunches that could be purchased from the school canteen.

Gathering Evidence

Teacher Perspective. In March 2006 the lead teachers from Ocean School were interviewed as a group using the following semi-structured questions.

- How do you presently teach statistics?
- What do you value in this way of teaching?
- What are the student achievement outcomes from this approach?
- Do you have any concerns about the way you teach statistics?
- What changes are you going to make in your teaching of statistics?
- Will this change in teaching alter what you value? Please explain
- Do you have any concerns about the new way you are going to teach statistics?
- What do you predict will be the effect on student achievement of teaching statistics through integration?

In October 2007 the lead teachers were reinterviewed as a group and asked the following semi-structured questions:

- How did you integrate your statistics teaching and learning programme?
- What did you learn from this approach?
- What has been the effect of this approach on your teaching and your students learning?

Student Achievement. The students were assessed in April and November (2006 and 2007) using asTTle (Ministry of Education, 2006). The asTTle tool (assessment Tools for Teaching and learning – www.asttle.org.nz) is an educational resource for assessing literacy and numeracy developed especially for the Ministry of Education by the University of Auckland. The asTTle tool provides teachers, students, and parents with information about a student's level of achievement, relative to the curriculum achievement outcomes, for levels 2 to 6 and national norms of performance for students in Years 4 to 12.

Procedures

The lead teachers chose to use asTTle because it provided a rich interpretation of student performance, and gave the lead teachers choice and control. The information gained allowed lead teachers to identify individual and group strengths and weaknesses, gauge progress, monitor patterns and trends, and to compare these with national standards (Tait-McCutcheon & Sherley, 2008).

A 40-minute paper and pencil test at Levels 2, 3, and 4 was created at the beginning and end of the 2006 and 2007 year. Each test had different questions but the test item content and test item difficulty remained the same as outlined in Table three.

Table 3
asTTle test item content and difficulty

	Test item content		Test item difficulty			
	Most		Few	Some	Most	Some
Level 2	Statistics	Number knowledge	Level 3		Level 2	N/A
Level 3	Statistics	Number knowledge	Level 2		Level 3	Level 4
Level 4	Statistics	Number knowledge	Level 3		Level 4	Level 5

Each student completed the asTTle test for their year level and achieved an asTTle Mathematics scale score. The scale score is based on the test items the students have answered correctly. Item Response Theory (IRT) is the model which generates these scores and "enables students to be compared on a common asTTle scale despite the items they actually answered, regardless of the time of year, and independent of others who sat the asTTle test with the student" (Ministry of Education, 2006, p.24). To provide more specific information and allow tracking of growth within levels, asTTle then equates each scaled score to a curriculum level (2, 3, or 4) using the descriptors of: basic (B), proficient (P) or advanced (A). These descriptors refer to the early, middle and late stages of development within each curriculum level (Ministry of Education, 2006). Table 4 shows the equivalent scale and curriculum level scores for achievement below, at, or above expectation.

Table 4
asTTle expectations for achievement

	Achievement below expectation	Achievement as expected	Achievement above expectation
Scale score	Below 25 points	25 to 35 points	Above 35 points
Curriculum	No change level score	1 curriculum sub-level (per year)	1 curriculum level (per 2 years)

The average gain for a student is just over one sub-level per year; however it is also realistic for teachers to expect students to move up to two sub-levels within a year (Ministry of Education, 2006). It should also be noted "within the above expectations a difference of more than 15 points represents a statistically significant difference and can be used to identify educationally meaningful change" (Ministry of Education, 2006, p. 6).

The asTTle test is normed as at November. Over the year the expected improvement would be from one year level norm to the next year level norm, for example from Year 5 November (2006) to Year 6 November (2007) the expected improvement would be the difference between the two norms 470 (Year 5) and 502 (Year 6) which is 32 points. As the initial testing occurred in April each year a norm for comparison was required. Assuming linearity this was determined by the formula: norm this year - norm last year) ∏ 12, which yields the monthly improvement in norms. For example November to April is 5 months so last year's norm plus 5 times the monthly improvement gives the norm for April this year. The Year 4 results are normed for November but there is no Year 3 norm to use for determining a norm for earlier than November Year 4.

Findings

Three themes emerged from the lead teachers' interview data from March 2006. These were the isolated nature of teaching statistics, the block teaching approach, and limited time within an already crowded curriculum. Each theme is discussed separately using the lead teachers' comments to illustrate.

The lead teachers noted that as a strand of the mathematics curriculum, statistics was previously taught in isolation either over a block of time, or one day a week. The usual outcome of delivering statistics in isolation was that students did not have the time to develop an in-depth understanding. Analysis of data was limited to surface feature understanding, and focussed more on requiring the students to produce a product or 'yes/no' response. This implies a more traditional pedagogical approach, which results in claims and contentions that are more deterministic (Tait-McCutcheon & Sherley, 2008) and is reinforced by Zevenbergen, Dole, and Wright (2004) who noted that:

> … while students may be strong on constructing graphs, they do not appear to be as strong on interpreting from the graphs and being able to transfer this information into decision making. (p. 291)

The block-teaching approach within an already crowded curriculum meant that teachers were forced to find situations to explain the statistics that were not always relevant or contextual to real world situations and problems. The time that was available was spent primarily on the mechanics of graphing rather than the interpretation (Pfannkuch & Wild, 2003).

> We do statistics at a busy time of the year and fitting it in was difficult. And we didn't look much into what is this graph telling us? It was mainly how do we make this graph? (Teacher A)

> The timetable is so crowded – often statistics didn't get the time that it deserved. (Teacher B)

> I was concerned about the length of time left to analyse graphs and improve on the statements the students made. (Teacher C)

Expectations of the time dedicated to the number strand through the Numeracy Development Project have placed additional pressures of the availability of time to teach the other strands. This impact was cyclical and it is proposed that each year the students encountered statistics within a limited amount of time and thus made limited progression in their statistical understandings. Restricted time and a crowded curriculum drove a need in the teachers to cover the achievement objectives rather than opportunities for students to experience the achievement objectives. As Pfannkuch and Wild (2003) found, the students had a propensity not to seek a deeper understanding of the data and interacted with the data superficially.

In October of 2007 each teacher was re-interviewed and asked to discuss how they had integrated their statistics teaching and learning programme, what had they learned from this approach and what had been the effect of this approach on their teaching and their students learning? Each teacher agreed that within integration it was important to uphold the significance of statistics and to make the significance explicit within the teaching. When integrating statistics with a subject such as physical education, learning intentions and success criteria from both the physical education and mathematics curriculum documents should drive the learning. This approach to teaching offered knowledge that is required on many different occasions, rather than knowledge that is infrequently used, and can therefore be classified as everyday rather than academic (Venville, Wallace & Rennie, 2004)

> I have started to look for natural links and ways to integrate statistics teaching and learning in other areas of the curriculum. The biggest change to my teaching would have to be that I don't look at statistics any more as a whole process of investigation from start to finish. I take the opportunity to discuss statistical displays with my class as opportunities arise and investigate situations and statements as they arise. I want to ensure that the statistical knowledge and outcomes are valued within the topic work and that they hold the focus. (Teacher B)

A seamless approach toward the teaching of statistics was required to ensure that statistical literacy is continually developed within a natural context.

> One thing that completely changed was the "what next?" And "so what?" questions. I never ever addressed these when I taught the old way, now everything leads to so what? What next? How can we use this? Why do we want to know this? The students now understand that you use statistics to make decisions that influence life … not do it because we have to learn it. Statistics has become a tool that they can use forever - it is not just a maths strand! (Teacher B)

In this study the teaching of statistics encouraged the development of deeper thinking skills and ensured more time was given to the analysis and interpretation of data. Aligned with this was the aim of starting where the children are at, both in terms of knowledge and interest.

> I am looking for critical thinking in the students' evaluative comments and in their knowledge of, and ability to use, graphs. It is important to provide the children with experiences within a real context, with block teaching we had to create contexts but it is more powerful to find teaching situations embedded within other curriculum topics. (Teacher B)

> I am trying to make statistics relate to them in the real world, by being related to other topics and not just at Maths time. Finding their interests within the topic. Stir up some interest in statistics – find a purpose that is meaningful to them. I had to let go my control of the statistics/integrated lesson, I had planned to go one way, the kids wanted to go in another – it wasn't always a quicker route! But it was their route and it worked (usually). I let them lead the lessons, let them challenge each other more – and they responded to that really well. (Teacher C)

Students

The 2006 data (n=56) included the students who were in the classes of the lead teachers and showed that the Year 4 students were achieving above the national mean in statistics, and the Year 5 and 6 students were achieving below the national norm. The results from the final asTTle test in 2006 showed that each year group was achieving above the national mean. The Year 4 students improved as expected (30 points) and the Year 5 and 6 students improved above expectation, with 160 and 150 points respectively.

Table 5
2006 initial and final scale and level results

Year level	Partici- pants (N=56)	asTTle mean scale score	Initial scale score	Final scale score	Improve- ment (> 15 sig- nificant)	asTTle mean level score	Initial level score	Final level scale	Improve- ment in curri- culum sub-levels
4	10	*410*	450	480	30	2 *P*	2 A	3 B	1
5	18	*470*	460	620	160	2 *A*	2 A	3 A	3
6	28	*502*	480	630	150	3 *B*	3 B	4 B	3

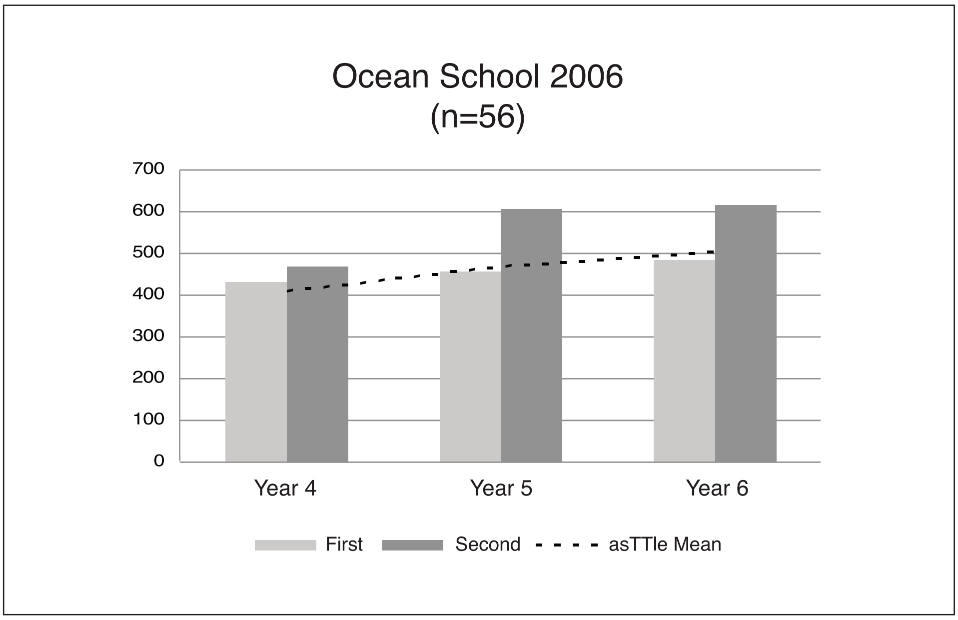

Figure 1: Comparison of the 2006 initial and final asTTle results and the national mean

The 2007 data (n=211) included all year 4 to 8 students in Ocean School and initial results showed that the Year 6 and 7 students were achieving above the national mean. This could be a reflection of the results these students achieved as Year 5 and 6 students during 2006. The Year 4, 5, and 8 students were achieving below the national mean. The end-of-year 2007 assessment showed that the Year 7 students had improved as expected (30 points), and the Year 4, 5, 6, and 8 students had improved above expectation (40, 69, 54, and 60 points respectively).

Table 6
2007 initial and final scale and level results

Year level	Partici-pants (N=56)	asTTle mean scale score	Initial scale score	Final scale score	Improve-ment (> 15 sig-nificant)	asTTle mean level score	Initial level score	Final level scale	Improve-ment in curri-culum sub-levels
4	52	*410*	397	437	40	2 *P*	2 P	2A	2
5	46	*470*	457	526	69	2 *A*	2 A	3 P	2
6	45	*502*	533	587	54	3 *B*	3 P	3 A	1
7	36	*541*	602	632	30	3 *P*	3 A	4 B	1
8	32	*638*	592	652	60	4 *B*	3 A	4 B	1

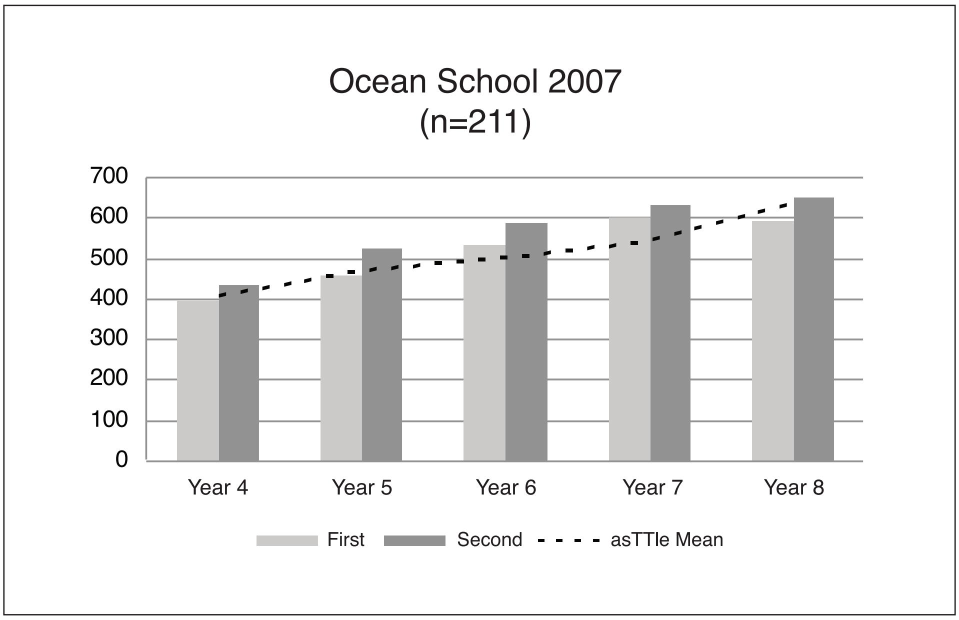

Figure 2: Comparison of the 2006 initial and final asTTle results and the national mean

Discussion and Conclusion

This research asked the question "what would the effect of contextually integrating statistical investigations and literacies into other curriculum areas be on student achievement?" The qualitative comments from the lead teachers and the quantitative results of students' achievement confirm that the answer to that question is that the difference in achievement was considerable. The levels of achievement within asTTle are as follows: less than 25 points indicates that the student has achieved below expectation, 25 to 35 points indicates achievement as expected, and an improvement of over 35 points indicates achievement above expectation. The 2006 findings showed that 18% of the students made expected achievement and 82% achieved above expectation. The 2007 findings showed that 17% of the students made expected achievement and 83% achieved above expectation. The contextual integration of the statistics teaching and learning programme was an integral part of the improved achievement outcomes in this research. However, the teachers' learning must also be acknowledged as contributing to the students' successes.

Participation in this project and professional development have increased the teachers' and students' personal and professional valuing of statistics as a context and content. The teachers have become more aware of the natural occurrence of statistical content and context within curriculum areas other than mathematics. This has resulted in real world learning experiences for the students that illustrate to them that statistical use and understanding is an everyday part of what they do in their own lives. Through regular encounters with rich contextual learning opportunities a foundation for statistical literacy is being developed. The teachers felt they were better planned to teach through their increased understanding of statistics content, and more prepared to teach through their increased experiences with statistics pedagogies.

> I have noticed the children have become more confident at making statements and using information and critically analysing it – reading a story in the paper and bringing it to school and challenging what it is saying and they are using the statistics information provided to do this! Before school! They read statistics information in the paper (had a whole lot about census), they start talking: "So what does this tell us? What could we use this for? What is the point in collecting this data? Why tell us this – it tells us nothing, we would need to know A or B if this was to be useful". During morning tea time! Then wanting to discuss it in class time…. They are self motivated statistics learners… (Teacher C)

References

Beane, J. A. (1995). Curriculum integration and the disciplines of knowledge. *Phi Delta Kappan, 76*(8), 616-622.

Beane, J. A. (1997). *Curriculum integration: Designing the core of democratic education*. New York: Teachers College Press.

Begg, A. (2002). Mathematics in the New Zealand curriculum: Curriculum concerns. *The New Zealand Mathematics Magazine, 39*(2), 3-15.

Begg, A., Pfannkuch, M., Camden, M., Hughes, P., Noble A., & Wild, C. (2004). *The school statistics curriculum: Statistics and probability education literature review*. Wellington: Mathematics Curriculum Reference Group, Ministry of Education.

Clarke, D. M. (1994). Ten key principles from research for the professional development of mathematics teachers. In D. B. Aichele, & A. F. Coxford (Eds.), *Professional development for teachers of mathematics* (pp. 37-48). Reston, VA: National Council for Teachers of Mathematics.

Cobb, G. W., & Moore, D. S. (1997). Mathematics, statistics and teaching. *American Mathematical Monthly, 104*, 801-823.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*, 13-20.

Gattuso, L., & Pannone, M. A. (2002). Teachers' training in a statistics teaching experiment. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics* (pp. 685-692), Cape Town., Voorburg, The Netherlands: International Statistical Institute.

Higgins, J. (2002). *Evaluation of the Advanced Numeracy Project. Exploring Issues in Mathematics Education* (2001). Wellington: Ministry of Education.

Higgins, J. (2004). *Evaluation of the Advanced Numeracy Project. Exploring Issues in Mathematics Education* (2003). Wellington: Ministry of Education.

Higgins, J. (2005). Pedagogy of facilitation: How do we best help teachers of mathematics with new practices? In H. L. Chick, & J. L. Vincent (Eds.), *Proceedings of the 29th annual conference of the International Group for the Psychology of Mathematics Education* (Vol. 3, pp. 137–144). Melbourne: PME.

Higgins, J., & Tait-McCutcheon, S. L. (2006). Contextually responsive facilitation. In F. Ell, J. Higgins, K. Irwin, G. Thomas, T. Trinick, & J. Young-Loveridge (Eds.), *Findings from the New Zealand numeracy development projects 2005* (pp. 59-66). Wellington, New Zealand: Learning Media.

McEntee, G. H., Appleby, J., Dowd, J., Grant, J. Hole, S., Silva, P., & Check, J. (Eds.), *At the heart of teaching: A guide to reflective practice*. New York: Teachers College Press.

Hord, S. M. (1997). *Professional learning communities: Communities of continuous inquiry and improvement*. Austin: Southwest Educational Development Laboratory.

Jaworski, B. (1994). *Investigating mathematics teaching: A constructivist enquiry*. London: Falmer Press.

Loepp, F. L. (1999). Models of curriculum integration. *The Journal of Technology Studies, 25*(2), 1-9.

Ministry of Education. (2006). *asTTle V4* [Computer program]. Wellington, New Zealand: Learning Media.

Moore, D. S. (2002). Teaching statistics as a respectable subject. In F. Gordon & S. Gordon (Eds.), *Statistics for the twenty-first century* (pp. 14-25). Washington DC: The Mathematical Association of America.

Pfannkuch, M., & Wild, C. J. (2003). Statistical thinking: How can we develop it? In *Proceedings of the 54th International Statistical Institute Conference*. Voorburg, The Netherlands: International Statistical Institute.

Rennie, L., Sheffield, R., Venville, G., &Wallace, J. (2005). *Ripples and tsunamis to curriculum integration: A comparative case study*. Paper presented at the Annual Conference of the Australian Association for Research in Education, Parramatta NSW.

Simon, M. (1995). Reconstructing mathematics pedagogy from a constructivist perspective. *Journal for Research in Mathematics Education, 26*(2), 114-145.

Sorto, M. A. (2006). *Identifying content knowledge for teaching statistics*. Paper presented at the International Conference on Teaching Statistics. Brazil

Tait-McCutcheon, S. L. & Sherley, B. (2008). Statistics professional learning and development. *Findings from the New Zealand numeracy development projects 2007* (pp. 107-111). Wellington, New Zealand: Learning Media.

Tait-McCutcheon, S. L. & Sherley, B. (2006). In the hands of the learner: The impact of self assessment on teacher education. In P. Grootenboer, R. Zevenbergen, & M. Chinnappan (Eds.), *Identities, Cultures and Learning Spaces* (Proceedings of the 29th annual conference of the Mathematics Education Research Group of Austalasia, pp. 353-359). Canberra: MERGA.

Venville, G., Wallace, J., & Rennie, L. (2004). *Curriculum conundrum: Integration, breadth and balance or specialisation, depth and integrity*. Keynote lecture presented at the Charting the Future: The Way Forward for Secondary Education Conference, Wellington, New Zealand.

Wallace, J., Sheffield, R., Rénnie L., & Venville, G. (2007). Looking back, looking forward: Re-searching the conditions for curriculum integration in the middle years of schooling. *The Australian Educational Researcher, 34*(2), 29-49.

Woodward, J., & Pfannkuch, M. (2007). Statistics teachers as scientific lawyers. In J Watson, & K., Beswick (Eds.), *Mathematics: Essential research, essential practice* (Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia, pp. 834-842). Hobart: MERGA.

von Glasersfeld, E. (1990). An exposition of constructivism: Why some like it radical. In R. B. Davis, C. A. Maher, & N. Noddings (Eds.), *Constructivist views on the teaching and learning of mathematics* (pp. 19-29). Reston, VA: National Council of Teachers of Mathematics.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Zevenbergen, R., Dole, S., & Wright, R. (2004). *Teaching mathematics in primary schools*. New South Wales: Allen & Unwin.

Author

Sandi Tait-MCutcheon, School of Educational Psychology and Pedagogy, Faculty of Education, Victoria University of Wellington, PO Box 17-310, Donald St, Karori, Wellington, New Zealand. Email: <sandi.mccutcheon@vuw.ac.nz>