TRAJECTORIES OF LEARNING IN MIDDLE YEARS' STUDENTS' STATISTICAL DEVELOPMENT

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The middle years of schooling (Grades 5 to 9; ages 10 to 14 years), critical in students' mathematical development, are also characterised by a dip in mathematics performance. Typically, the greatest drop occurs at the transition between primary and high school. StatSmart *is a large-scale longitudinal study addressing statistics teaching and learning in the middle years in three states in Australia, one of which has Grade 7 as part of the primary school, whereas in the other two states Grade 7 marks the start of high school. Student understanding of statistics is measured three times using Rasch measurement to compare performances at different points in time. Two cohort measures indicated that there was a plateau in performance between the first and second year of high school, rather than at the primary/high school transition. The trajectories of learning identified are discussed.*

BACKGROUND

The middle-years of schooling are those transition years in which pre-adolescent and adolescent students move from the elementary school into the high school setting, typically Grade 5 to Grade 10 of schooling with the primary/high school transition occurring around Grade 6. Several studies have documented a plateau in both literacy and mathematics achievement in these years, with the greatest dip in performance typically occurring at the transition between primary and high school (e.g., Breed & Virgona, 2006; Hill & Russell, 1999). *StatSmart* is a 3-year project aimed specifically at improving middle-years' students learning outcomes in statistics through influencing teaching approaches and pedagogy (Watson, Callingham & Donne, 2008).

The "big ideas" of statistical literacy at the school level, as suggested by Watson (2006), provide the foundation for the professional learning program in *StatSmart*. The developmental nature of these ideas is acknowledged, and teachers are encouraged to identify students' current understanding and to build on this using a range of teaching approaches. Technology use is an integral part of the program, and all teachers integrate Tinkerplots software (Konold & Miller, 2005) into their teaching programs.

These big ideas also underpin the choice of items used to measure students' statistical literacy as part of the evaluation of *StatSmart*. Hence there are items addressing sampling, variation and informal inferences, as well as more curriculum-focussed items dealing with average, probability and graphing. The items have all been used in previous studies, and work together to create a scale of statistical literacy (Callingham & Watson, 2005; Watson & Callingham, 2003).

METHOD

The *StatSmart* study has a complex design of data collection intended to measure teacher and student change and makes use of linked surveys with a common core of items to enable the use of Rasch analysis to measure change without having to use exactly the same items each time (Bond & Fox, 2007). This report addresses only students' outcomes from the first two years of data collection in 2007 and 2008. All items were anchored to the original survey at the start of the project in 2007, and hence student performance can be directly compared across time.

The students are in a variety of schools in three different states of Australia. Each year of the study teachers participating in *StatSmart* nominate classes to take part in the project and these students undertake a survey of statistical literacy early in the school year (typically April or May) and again towards the end of the year. In addition students are tracked and undertake a third survey one year later. Table 1 shows the sample size for each phase of the project to date.

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Table 1. Overall student sample sizes for Phases 1 and 2 of StatSmart

	2007 (Phase 1)	2008 (Phase 2)
April/May	N = 1205	N = 999
November	N = 1168	N = 1761 (including 482 tracked students)

Students were in Grade 5 to Grade 10, which includes the transition from elementary to high school. Because teachers nominated classes for participation in the testing, the range of grades involved varied from Phase 1 to Phase 2 in each participating state.

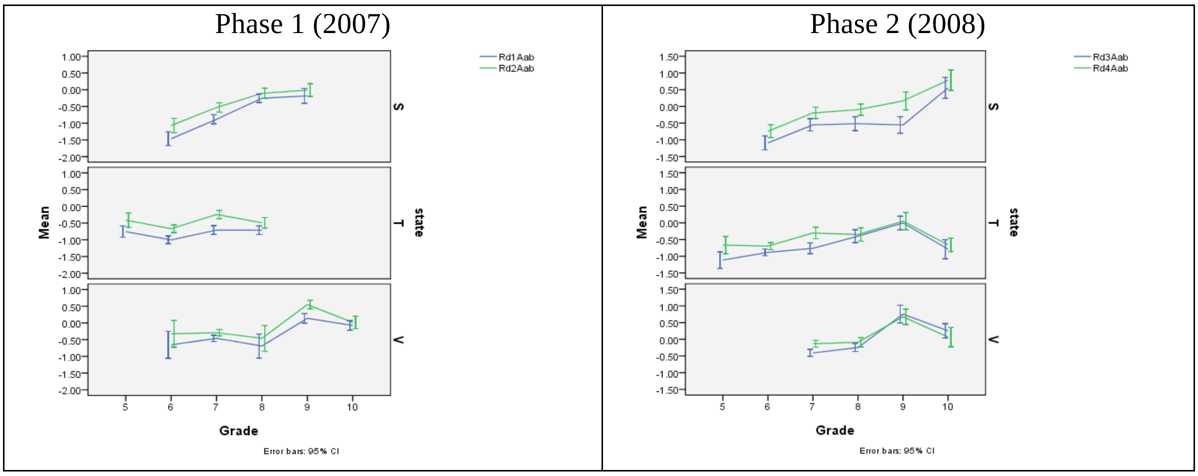
Of particular relevance to this report is the fact that, because of varying patterns of educational organization in different states of Australia, some students completed Grade 7 in primary school whereas for others Grade 7 marked the first year of high school. In both instances, the mean age of the students involved in Grade 7 was around 12 years and 3 months. The primary/high school transition is organizational rather than age-based. The different organization has particular relevance to the tracking process. It is notoriously difficult to follow students across this transition but, because many of the students were in schools that had both elementary and high school classes, reasonable numbers were able to be followed. Table 2 shows the composition of the tracked longitudinal sample. The number of students in the first year of high school is shown in italics.

Table 2. Tracked Longitudinal Student Sample from StatSmart

Start Grade:	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10
State S		27	*50*	73	34	
State V			99	*23*	16	8
State T	27	22	84	*19*		
Total	27	49	233	115	50	8

FINDINGS

Figure 1 shows the results from student tests at the start and end of 2007 and 2008, from the two cohorts of students forming Phase 1 and Phase 2 of the project broken down by grade group. Of interest are the very similar patterns of performance across the grades shown in each of the two phases.

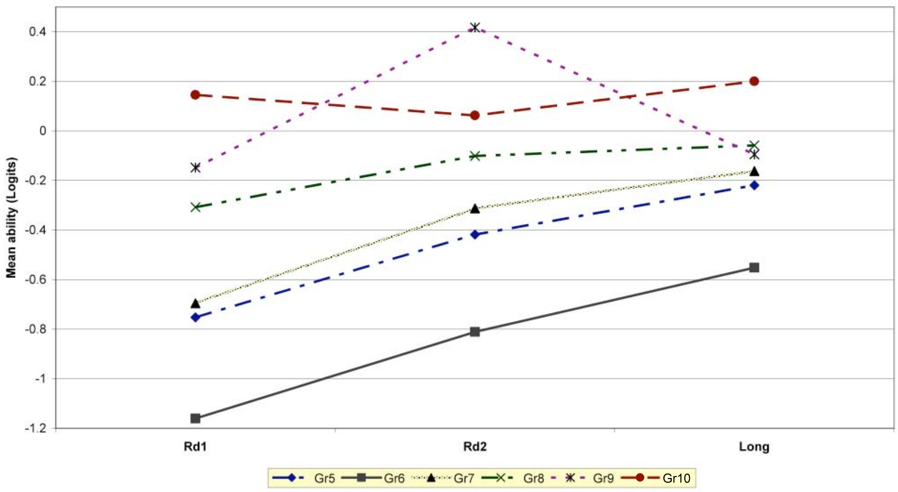


Note: State S includes Grade 7 in the primary school

Figure 1. Results by grade group from Phase 1 and Phase 2 of StatSmart, excluding tracked students

It is the patterns of performance that are of interest. In states T and V, where Grade 7 is the first year of high school, there is improved performance between Grades 6 and 7, and a slight but noticeable dip in performance between Grades 7 and 8. In contrast, in state S, where Grade 8 is the first year of high school, performance plateaus between Grades 8 and 9. This finding suggests that the change in school context from primary to high school is less of an issue when learning statistics than it may be in other parts of the mathematics curriculum.

Figure 2 shows the aggregated growth in performance from the tracked students in all states at three points in time: the start and end of 2007 and in the follow up longitudinal test at the end of 2008. The grades shown are the start grades in 2007. Results from those students in Grades 5 and 10 should be treated cautiously because of the small numbers of students in these grades. Overall, the performance generally improves monotonically from Grade 6 to Grade 9. Those students who started in Grade 6 continued to develop from Round 2 testing to the Longitudinal test, undertaken when these students were in Grade 7, at almost the same rate as they did during the first year. Students who started in later grades, however, show slower rates of growth in the second year. This finding is broadly consistent with the previous analysis because the aggregation of students from all states would tend to obscure the variation from grade to grade shown across the states in Figure 1.



Note: Rd 1 and Rd 2 findings are from the early and late testing in the same grade, Long findings are from the same students one year later.

Figure 2. Tracked students by start grade

DISCUSSION

The findings from a consideration of performance across grades and growth over time on a test of statistical literacy appear to indicate that statistical understanding improves during the middle years until students reach the second year of high school after which it plateaus or falls. This result raises the issue of what is happening in classrooms in terms of both curriculum and pedagogy that might affect students' outcomes in this way and suggests that the early years of high school may be critical to the continued development of statistical understanding.

In the curriculum documents from the states of Australia involved in the project, the early years of high school are where statistical ideas begin to become formalized and terminology becomes more complex. The curriculum of State T, for example, states that by the end of Grade 8 students should experience:

> Explicit teaching of data representation such as box and whisker plots so that the student can choose to use this type of graph to compare different sets of data;
> Using a variety of approaches to determine and represent sample (event) spaces and calculate corresponding probabilities (Department of Education, 2008, p. 70).

If this statement is compared with that for the beginning of Grade 7, the first year of high school, the approach is much more exploratory and informal. For example, students should experience:

> Exposing students to a range of ways to record data and developing their confidence to construct different graphs and charts, including making choices about the effective use of technology (Department of Education, 2008, p. 51).

These statements indicate that not only does the content become more formal and complex, but also that the teaching moves from exploratory approaches to more traditional methods.

It is important and necessary that students move towards more formal understanding of statistics as they progress through school, and are able to interpret data within social and mathematical perspectives. The Statistical Literacy hierarchy identified by Watson and Callingham (2003) includes these two aspects. Students, however, find it difficult to progress beyond the level called Consistent non-critical, in which they can manipulate the mathematics but not interpret the statistics consistently with respect to social settings (Watson, 2006, p. 253). It could be that the increased formality of statistics teaching as the concepts become more difficult may prevent students developing the deep understanding of both the mathematical aspects of statistics and the interpretation of these within social contexts. Reports from teachers in the *StatSmart* project certainly imply that they have tried to move away from text book approaches to more realistic situations exemplified by this comment from a teacher in State T: “I am much more aware of associating the curriculum requirements with a real life situation and using real data sets to teach concepts.” The final results from the *StatSmart* project may shed additional light on the complex interactions between statistics learning and teaching in the middle years of schooling.

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