2017

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This paper discusses the National Assessment Program for Literacy and Numeracy (NAPLAN) performance of Years Five, Seven and Nine students in standardised tests prior and post the implementation of a mobile learning initiative in a Western Australian school for boys. The school sees the use of ICT as important in enhancing its potential to deliver optimal educational outcomes. However, the School is also cognisant of the shared concern of teachers and parents in the school community about an over-reliance on mobile devices for learning, to the detriment of students' accomplishments in literacy and numeracy. The paper examines NAPLAN results from standardised test scores prior and post the mobile learning initiative at the School and in comparison to national data. Literacy and numeracy results were analysed between two periods: prior to 2010 in which the mobile learning initiative was not implemented at the School and between 2010 and 2012, in which the mobile learning initiative was implemented in Years Five, Seven and Nine. It is argued that the implementation of mobile learning has had a minimal effect on student performance as gauged by standardised testing.

Introduction

The United Kingdom and the United States have the longest histories of standardised high-stakes testing and the reporting of student achievement, dating back to the 1980s (Selwyn, 2011; Carmichael, MacDonald & McFarland-Piazza, 2014). Australia has followed in their footsteps in implementing high-stakes testing which is an important policy agenda for the Australian Government (Dreher, 2012; Hardy, 2014). Furthermore, Australia was at the forefront in implementing mobile learning through 1:1 laptop programs, with the Methodist Ladies College, Melbourne, said to have provided the earliest example of such a program in the world in 1989 (Bebell, 2005). Since the Federal Government's promotion of a *Digital Education Revolution* in schools in 2007, most students in Australia in Years Nine to Twelve have been provided with access to a 1:1 device to further improve their learning through information and communication technology (ICT) (ANAO, 2011), and the use of mobile devices for learning continues to this day.

Discussion in Australia about the use of mobile devices in class and their impact on standardised high-stakes testing continues, particularly in light of shared concerns by parents and teachers (Bate, Macnish & Males, 2012). Since the onset of the technology penetration in schools in the U.S., reading and mathematics test scores at the high school level are no higher than 30 years ago (Grimes & Warschauer, 2008). According to Cuban (2006), for example, there is no link between students having access to a 1:1 laptop program and improved test scores. However, in studies with similar goals but different participants, such as that by Lei and Zhao (2007), links *were* found between students having access to a 1:1 laptop program and improved test scores. Clearly, more research is required.

In Australia, national standardised testing was introduced in 2008 with the *National Assessment Program for Literacy and Numeracy* (NAPLAN). The testing under this program takes place each year at the same time across the country. The data provides policy makers, school communities and parents with information about student performance, thereby ensuring greater accountability of schools to improve teaching and learning (Belcastro & Boon, 2012; Wildy & Clark, 2012). NAPLAN is a test of literacy and numeracy skills over time linked to a national curriculum. NAPLAN consists of tests in the domains of: reading, writing, language conventions (spelling, and Grammar and punctuation,) and numeracy. Annually, NAPLAN testing is carried out in Years Three, Five, Seven and Nine across all schools in Australia (ACARA, 2016). NAPLAN is similar to standardised testing programs in the UK, Singapore, Germany, China and the U.S. (Rotberg, 2006; Mattei, 2012).

Research context

This paper is derived from a broader study that measured the impact of a mobile learning initiative that was based on a 1:1 laptop implementation at a school for boys in Western Australia ("the School"). For the purposes of this research, mobile learning is taken to mean the use of a mobile device for educational purposes. Crompton (2013) defined mobile learning as learning that occurs through both social and content interactions, using a personal electronic device. The personal electronic device used in the current research was typically a laptop computer. The School began a program of gradual deployment of student-owned laptops in 2010. As at 2016, all students at the School between Years Five and Ten are provided a laptop which is parent funded, while students in Years Eleven and Twelve are required to use their own device as part of a 'bring your own device' (BYOD) program. Two cohorts were the subject of the broader study which spanned three years. These cohorts were a Year Five (junior school) group that progressed to Year Seven over a three-year period, and a Year Seven (middle school) group that progressed to Year Nine over the same period. For the purposes of this paper, the Year Five group is referred to as Cohort A ($n = 56$) and the Year Seven group as Cohort B ($n = 136$). The School itself is a Catholic boy's school that offers an education from Kindergarten to Year Twelve. The School was by no means an early adopter in moving to 1:1 student-owned laptops. However, it recognised the need to better prepare its students for life in an increasingly digital world. The School also discerned that there are opportunities to provide a more engaging and relevant teaching and learning environment through the integration of ICT across the curriculum.

Lei and Zhao (2008) reported that a number of studies have sought to gauge the impact of ICT, using approaches based on pre- and post-testing (Rockman, Walker & Chessler, 2000; Gulek & Demirtas, 2005; Silvernail & Gritter, 2005; Shapley et al., 2009). The purpose of this paper is to discuss the School's performance in NAPLAN testing pre- and post- the implementation of the mobile learning initiative in 2010.

Methodology

As discussed, this paper is underpinned by a longitudinal study that used a mix of methods to gauge the implementation of a mobile learning initiative at a private school in Western Australia. One of the core research questions of the broader study was to investigate the educational impact of the mobile learning implementation on literacy and numeracy outcomes. Two methods of analysis were adopted:

- Cohort analysis of mean NAPLAN scores in five domains pre-mobile device implementation (2008, 2009 and 2010) and post-mobile device implementation (2011 and 2012) for years Five, Seven, and Nine.
- Cohort analysis of learning gains in five domains pre-mobile device implementation (from 2008 to 2010) and post-mobile device implementation (from 2010 to 2012) for years Five to Seven and Seven to Nine.

The focus of this paper is on discerning changes to student performance post-mobile learning implementation. The research commenced in February 2010 and NAPLAN testing was undertaken three months after the commencement of the mobile learning initiative in May 2010, making it more or less a pre-test in the context of the broader longitudinal study.

The description of NAPLAN results draws on five scales, one for each of the domains of Reading, Writing and Numeracy and two for Language Conventions (Grammar and punctuation, and Spelling). These five scales span all year levels from Year Three to Year Nine and describe the development of student achievement according to ten bands on the scale. The scales are designed so that any given score by any student in Australia can be interpreted in the same way over time and represents the same level of achievement. For example, a score of 700 in Numeracy will have the same meaning in 2012 as in 2010, enabling improvements to be gauged over time. Each domain is divided into ten bands on the scale to cover the full range of student achievements tested. The bands are used for reporting student performance at each year level. The Year Three report comprises bands one to six, Year Five bands three to eight, Year Seven bands four to nine, and Year Nine bands five to ten (ACARA, 2016); for further information about NAPLAN, see http://nap.edu.au.

Analysing the NAPLAN results for cohorts pre- and post- the 1:1 mobile learning initiative helps to gauge the impact of mobile learning in the learning areas of literacy and numeracy. NAPLAN testing was introduced in 2008 so only three years of data can be used prior to the mobile learning implementation at the School in 2010. For this analysis, 2008, 2009 and 2010 results for Years Five, Seven and Nine were compared to 2011 and 2012 results for the same years. Writing had not been included in the analysis due to the changes in the Writing section of NAPLAN test from 2011. A move from narrative writing to persuasive writing was approved by Australian State Ministers in 2010 following extensive piloting (Turvey, 2012).

In addition to analysing mean scores, NAPLAN data also provided an opportunity to compare the learning gains of cohorts to previous years where students did not have access to a mobile learning device. For this analysis, learning gains for Years Five and Seven from 2008 to 2010 were compared to learning gains for the same years from 2010 to 2012. There were no control groups due to the scale of the mobile learning implementation at the School.

Ideally, when comparing schools it is useful to select 'like schools' based on the *Index of Community Socio-Educational Advantage* (ICSEA). However, as there were a limited number of male-only schools that were similar in ICSEA to the School in this study, the School is compared with males nationally. Mean scores for students at the School is presented alongside corresponding data for males nationally. For every mean NAPLAN test score, a corresponding 'Uncertainty of the mean' is provided (in terms of a 95% confidence interval (CI)). A 'One-way ANOVA (analysis of variance) for summary data' is undertaken to determine when a difference between a mean for the students at the School and the corresponding mean for males nationally is statistically significant at both $p<0.01$ and $p<0.05$ levels. The One-way ANOVA is also used to identify statistically significant differences in learning gains (at both $p<0.01$ and $p<0.05$ levels) between students at the School and males nationally, and between students pre-mobile learning implementation (Years Five to Seven and Seven to Nine, 2008 to 2010) and post-mobile learning implementation (Years Five to Seven and Seven to Nine, 2010 to 2012).

Results

Cohort analysis of mean NAPLAN scores

Figure 1 provides a summary of NAPLAN test results for Year Five students for the years 2008 to 2012, for both the School and all males nationally. Each bar in the figure represents the mean score for a particular year for the NAPLAN area indicated; the School is shown in green and the national male mean in blue. Cohort A is shown as Year Five students in 2010 (first year of study).

Over the five-year period 2008 to 2012 (inclusive), the mean score recorded by the School was roughly +20 marks higher than that recorded by Year Five males nationally for Reading and Spelling, and Grammar and punctuation. For Numeracy, the margin was larger, at about +40 marks in 2008, 2009 and 2011. For Persuasive Writing, a roughly +20 mark gap was observed in 2011 and 2012. In 2010 (Cohort A) the Year Five Cohort scores for Spelling, Grammar and punctuation, and Numeracy were approximately 10 marks above the mean recorded nationally by males. The Year Five School results are consistent across the period 2008 to 2012, with 2010 being the only year that recorded lower scores than the other years.

Figure 2 displays the School mean score compared to the national mean score for males in Year Seven. Cohort B is shown as Year Seven students in 2010 (first year of study) and Cohort A is shown as Year Seven students in 2012 (third year of study).
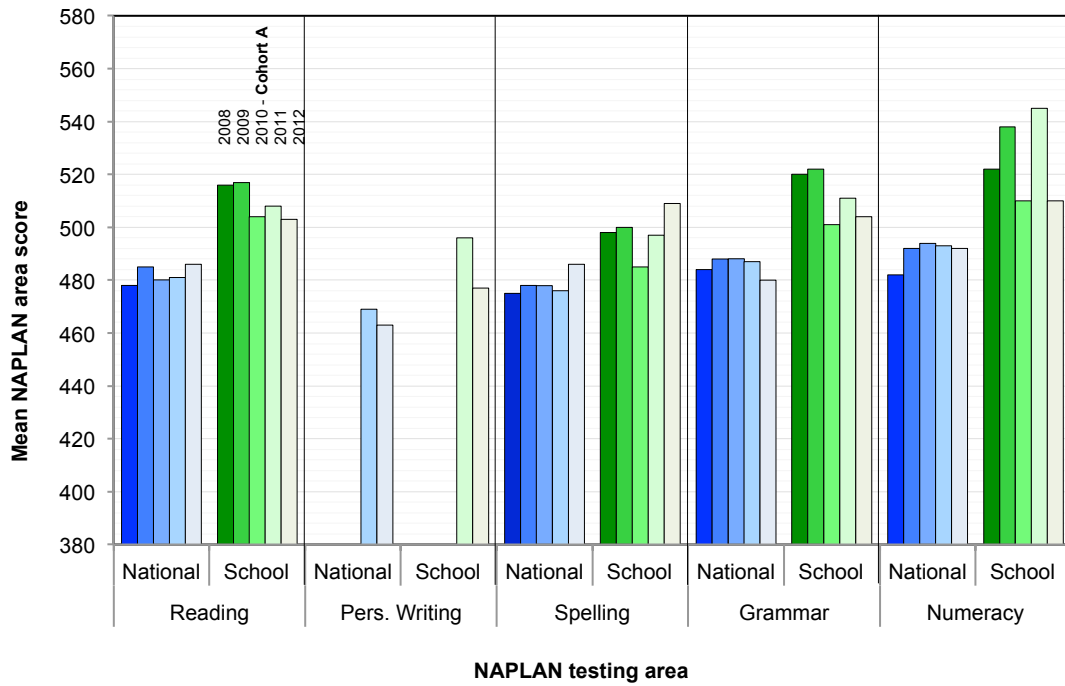
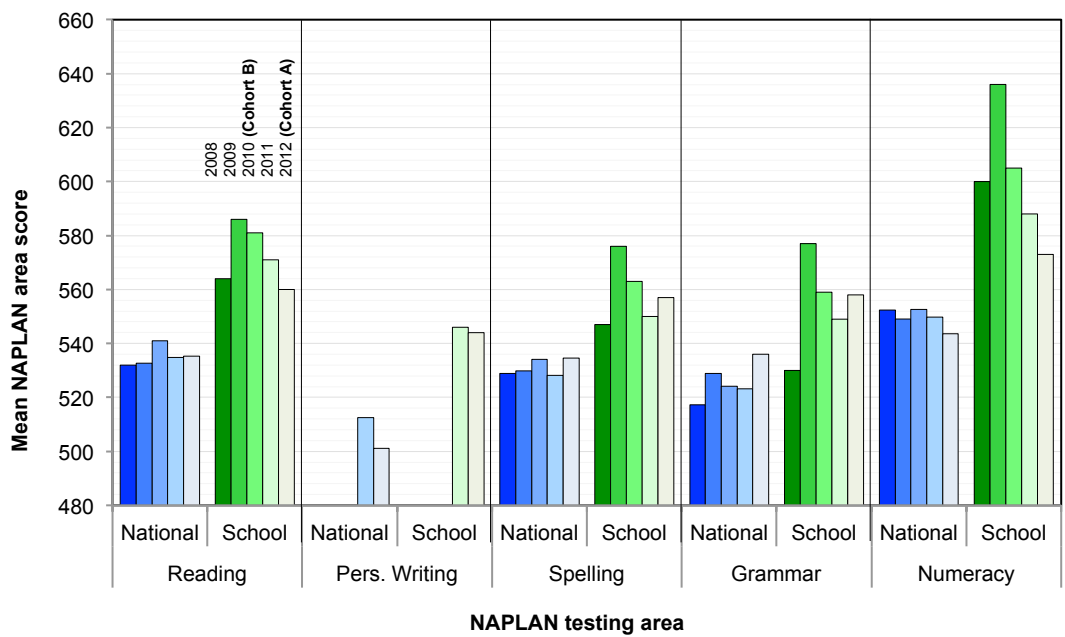Figure 1: Year Five NAPLAN test results 2008-2012: School vs. males nationally

Figure 2: Year Seven NAPLAN test results 2008-2012: School vs. males nationally

Over the five-year period 2008 to 2012 (inclusive), the mean score recorded by the School was roughly +30 marks higher than that recorded by Year Seven males nationally (in the four areas excluding Persuasive Writing). For Persuasive Writing, a +30 mark gap was observed in 2011 and 2012. In relative terms, the above margins represent a difference of about +5.5% for all domains. The 2009 Year Seven pre-mobile learning cohort at the School scored particularly highly in the four domains. In this year the margin between the School and Year Seven males nationally was on average about +9.5% in relative terms. In the years since the results of 2009, the School's results have tended to return to a position closer to, but still above, the Year Seven male national results.

Figure 3 displays the School's mean score compared to the national mean score for males in Year Nine. Cohort B is shown as Year Nine students in 2012 (third year of the study).
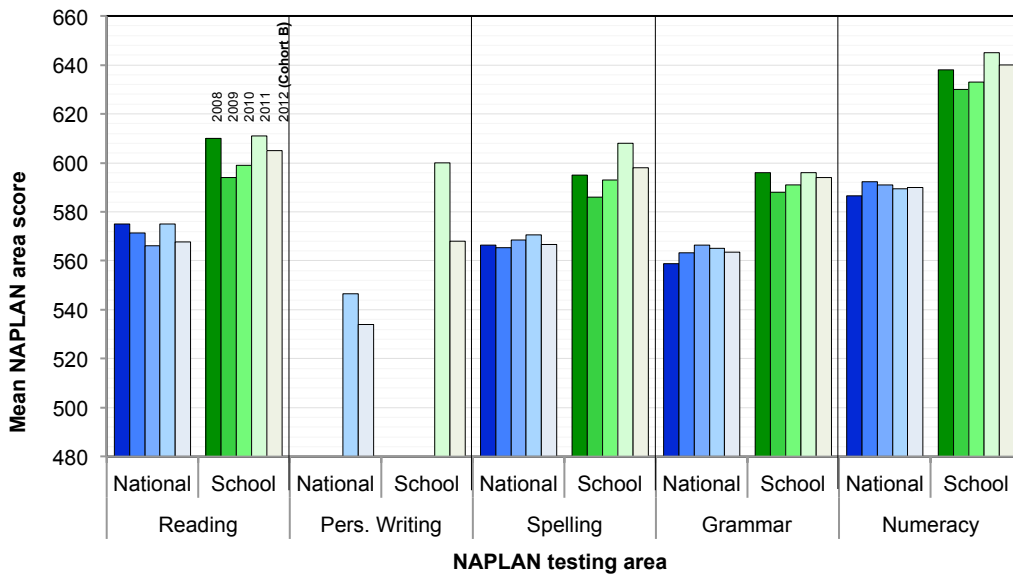

Figure 3: Year Nine NAPLAN test results 2008-2012: School vs. males nationally

Over the five-year period 2008 to 2012 (inclusive), the mean score recorded by the School was roughly +30 marks higher than that produced by Year Nine males nationally in Reading and Spelling, and in Grammar and punctuation. For Numeracy, the margin was slightly more at about +50 marks. For Persuasive Writing, a +40 mark gap was recorded in 2011 and 2012. In relative terms, the above margins of +30, +40 and +50 marks represent differences of about +5%, 7.5% and 8.5%, respectively. The Year Nine School results are consistent across the period 2008 to 2012, with no one year being particularly strong or weak.

Overall, the data indicates that the School has performed consistently better than the national average in all domains between 2008 and 2012. The implementation of the mobile learning initiative appears to have had no discernible impact.
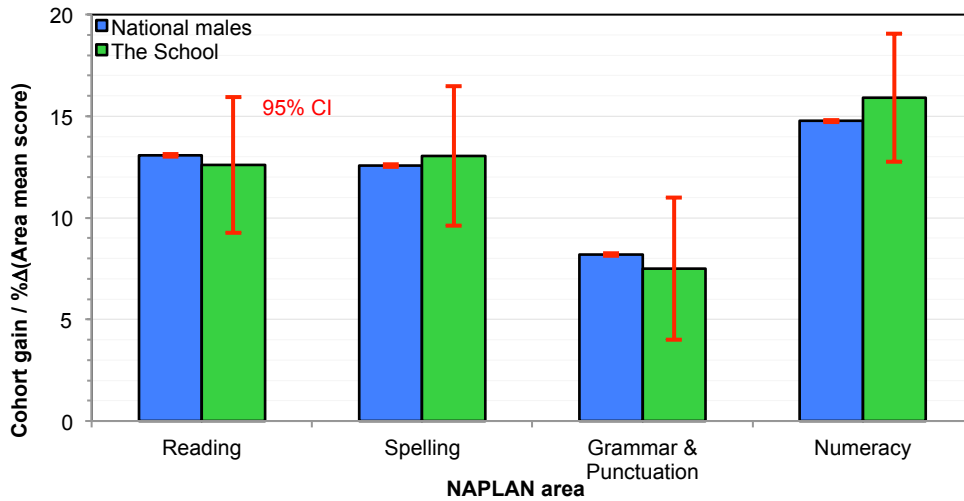
Figure 4: Cohort gains Years Five to Seven 2008-2010 (pre-mobile learning initiative)
(relative percentage)

Cohort analysis of learning gains

The above analysis from 2008 to 2012 shows that each year level is unique in terms of its mean and its relationship to the national average. It is, therefore, also useful to consider how each cohort might perform over time in terms of learning gains. Figure 4 shows the gains from Year Five to Year Seven in all domains for the School and males nationally between 2008 and 2010 (pre-mobile learning initiative); Figure 5 presents the same data between 2010 and 2012 (i.e. for Cohort A).
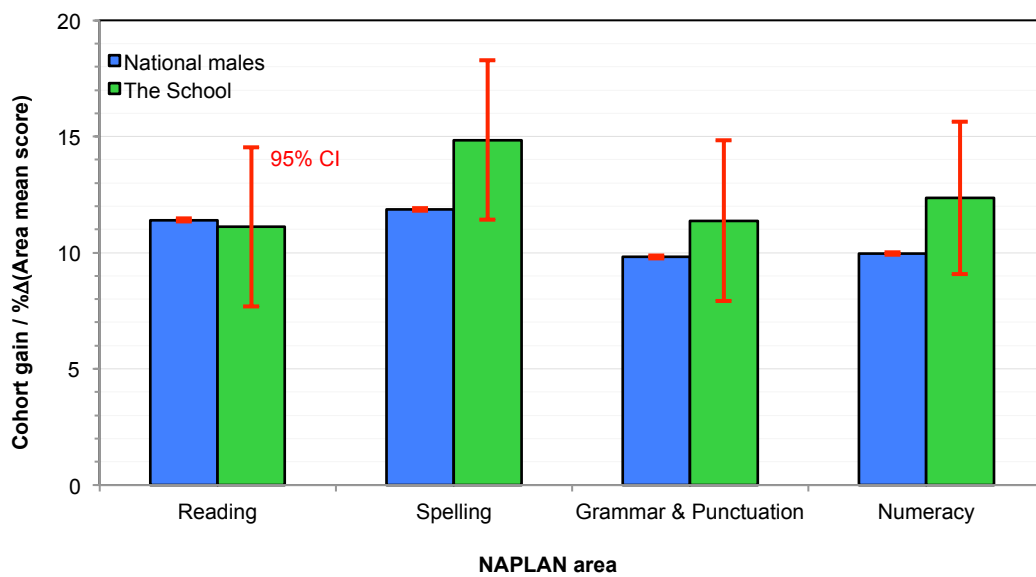

Figure 5: Cohort gain Years Five to Seven 2010-2012 (Cohort A) (relative percentage)

Between 2008 and 2010, the four domains recorded differences in cohort gain between the School and males nationally of about one per cent (relative). None of the differences in cohort gains between the males at the School and males nationally were statistically significant at the $p < 0.05$ level. Similarly, between 2010 and 2012, differences in cohort gains between the School and males nationally were not statistically significant at the $p < 0.05$ level, although it is interesting that School gains were higher than national gains in three of the four domains.

Figure 6 shows learning gains from Year Seven to Year Nine in all domains for the School and males nationally between 2008 and 2010 (pre-mobile learning initiative). Figure 7 presents the same data between 2010 and 2012 (i.e. for Cohort B).
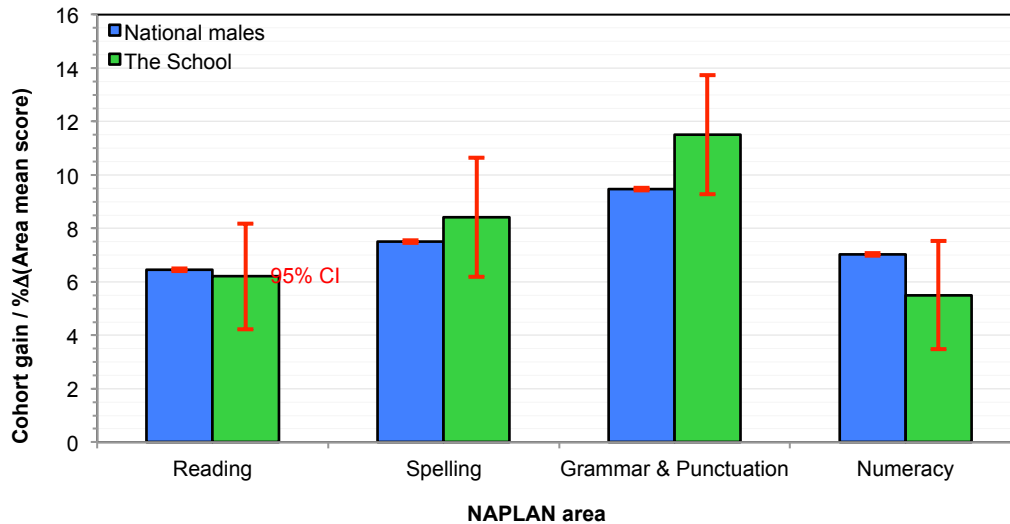

Figure 6: Cohort gain Years Seven to Nine 2008-2010: School vs. males
nationally (pre-mobile learning initiative) (relative percentage)

Between 2008 and 2010, differences in cohort gains between the School and males nationally were negligible and not statistically significant at the $p < 0.05$ level. For Numeracy, the result was unusual in that the cohort gain for males nationally was greater than that achieved by the School. Between 2010 and 2012, differences in cohort gains between the School and males nationally were also negligible and not statistically significant at the $p < 0.05$ level. However, cohort gains achieved by males nationally were greater than those achieved by the School in three of the four domains.

Figure 8 plots the cohort gains for Year Five to Year Seven as a percentage for the 2008 to 2010 pre-mobile learning cohort compared to the post-mobile learning cohort 2010 to 2012 (Cohort A). Figure 9 plots the cohort gains for Year Seven to Year Nine as a percentage for the 2008 to 2010 pre-mobile learning cohort compared to the post-mobile learning cohort 2010 to 2012 (Cohort B).
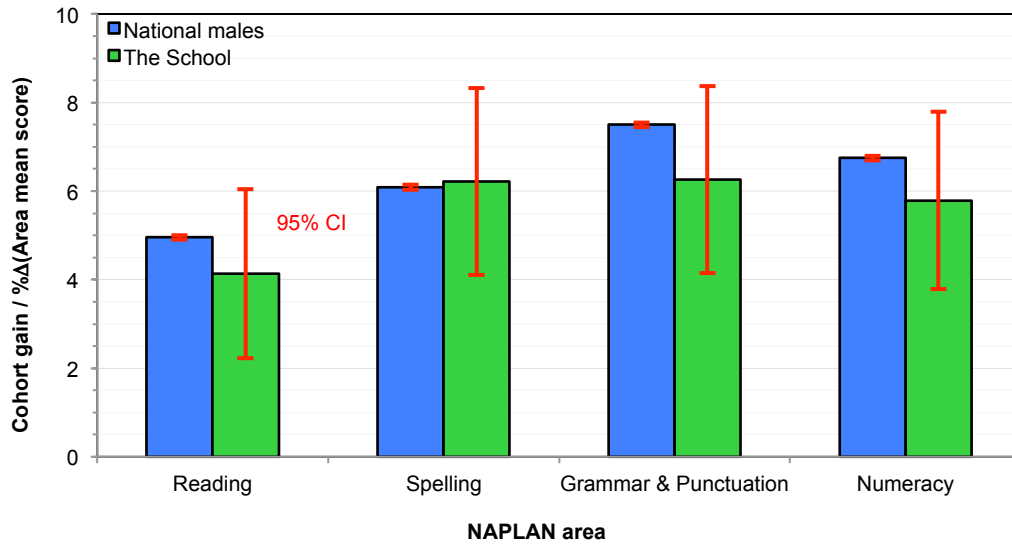
Figure 7: Cohort gain Years Seven to Nine 2010-2012 (Cohort B) (relative percentage)
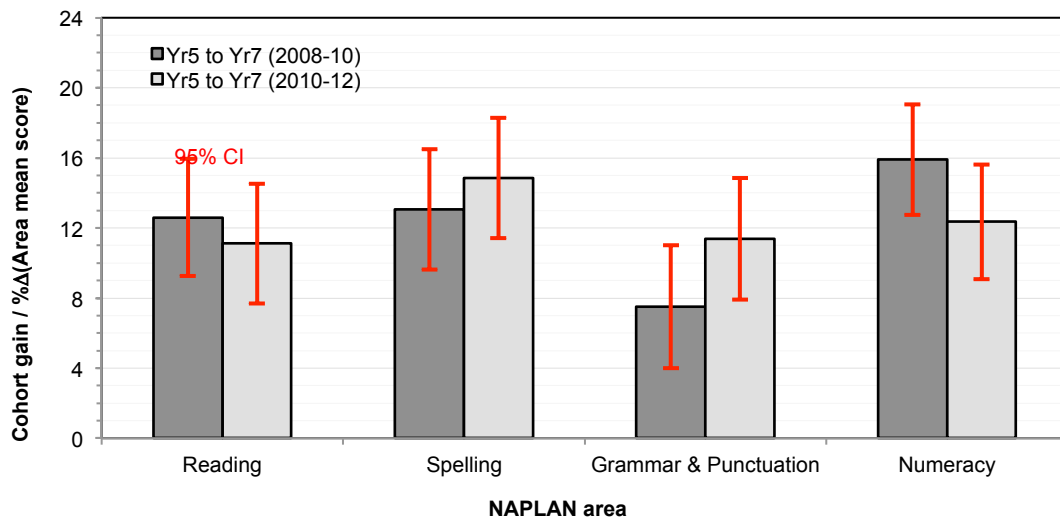
Figure 8: School's cohort (Cohort A) gains Years Five to Seven: 2008-2010 vs. 2010-2012 (relative percentage)

For Years Five to Seven, Reading and Numeracy 2008 to 2010 gains were marginally greater than the 2010 to 2012 gains; for Spelling, and Grammar and punctuation the 2010 to 2012 gains were greater than the 2008 to 2010 gains. None of the differences in gains were statistically significant at the $p < 0.05$ level.

Figure 9: School's cohort (Cohort B) gains Years Seven to Nine: 2008-2010 vs. 2010-2012 (relative percentage)

For Years Seven to Nine, differences between 2008-2010 and 2010-2012 cohorts in Reading, Spelling and Numeracy were negligible and not statistically significant at the $p < 0.05$ level. However, the difference in 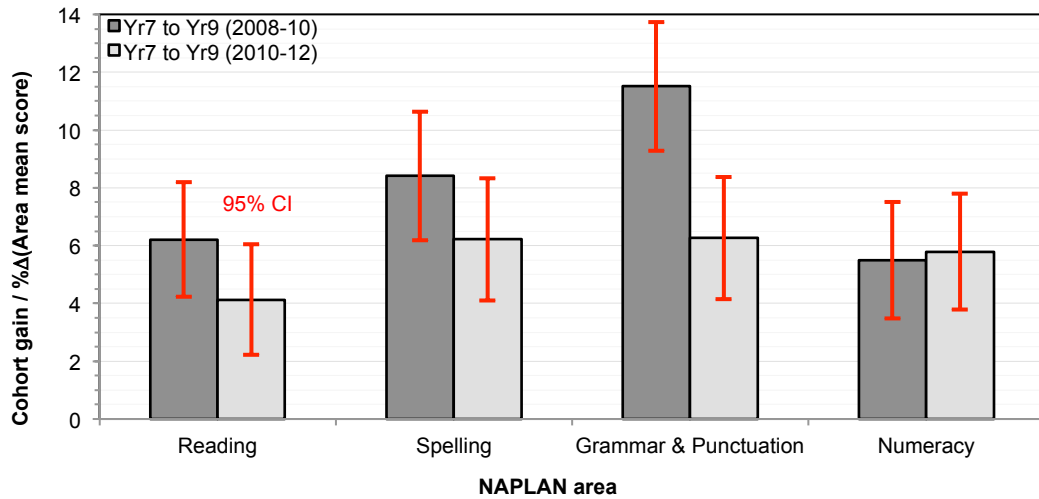gains for Grammar and punctuation was 26 marks (absolute) and 5.2% (relative). A One-Way ANOVA test (Table 1) revealed that the difference between the 2008 to 2010 cohort gain and the 2010 to 2012 cohort gain was statistically significant at the $p < 0.01$ level.

Table 1: One-way ANOVA of summary data test results for
Years Seven to Nine cohort gain data 2008-2010 vs. 2010-2012

Cohort gain	Area	School 2008-10			School 2010-12			ANOVA results			
		N	Δ Mean (%)	SD. (%)	N	Δ Mean (%)	SD. (%)	Δ [(2010-12) - (2008-10)] (%)	95% C.I.	F	Sig.
Δ (Year 7 to Year 9)	Reading	134	6.2	11.8	135	4.1	11.5	-2.1	1.9	2.185	0.141
	Spelling	134	8.4	13.1	134	6.2	12.7	-2.2	2.2	1.948	0.164
	Grammar and punctuation	134	11.5	12.9	134	6.3	12.6	-5.2	2.2	11.14	0.001**
	Numeracy	134	5.5	12.0	135	5.8	12.0	0.3	2.0	0.042	0.838

Note. ** Significance at $p < 0.01$ level; * significance at $p < 0.05$ level

Overall, Years Five to Seven cohort gains were mixed, with no discernible patterns evident. This result somewhat contrasted with the Years Seven to Nine cohort gains as for three of the four domains, the 2010 to 2012 post-mobile learning cohort gain was less than the 2008 to 2010 pre-mobile learning cohort gain. For Grammar and punctuation, the difference in cohort gain was statistically significant.

Discussion

Since the introduction of NAPLAN, a national curriculum, and the *My School* website, parents and teachers have had access to vast amounts of information about national literacy and numeracy, and to data about school performance (Klenowski & Wyatt-Smith, 2012). The measure of student performance in NAPLAN at the School which was the subject of this research is important, as parents seeking the best educational outcomes may select what they perceive as high performing schools to improve their child's chances of educational success (Bate, Macnish & Males, 2014).

Research into the application of ICT for student learning suggests that a move towards student ownership of mobile devices may yield significant benefits, particularly in terms of student engagement (Mouza, 2008; Bate, 2010; Bebell & Kay, 2010; Keengwe & Bhargava, 2014). The findings reveal a school that performed consistently higher than the national average in all areas of NAPLAN indicating good teaching and support structures are in place. Whether these preconditions are necessary for the implementation of mobile learning initiatives may be a worthy question for future research. Mean scores in all domains remained stable from pre- to post-mobile learning implementation suggesting that the implementation of the mobile learning initiative resulted in no significant impact. This finding is consistent with other studies (Grimes & Warschauer, 2008; Bebell & O'Dwyer, 2010; Won Hur & Oh, 2012; Fabian, Topping & Barron, 2016) which also reported negligible impacts on student learning arising from mobile learning implementations, in this case laptop computers. In Cohort B, however, cohort gains in three of the four domains were less than the 2008 to 2010 pre-mobile learning cohort gains and in Grammar and punctuation, a statistically significant decline was recorded in learning gains between 2008-2010 (pre-mobile learning) and 2010-2012 (post-mobile learning) in Years Seven to Nine. It could well be that the commencement of the 1:1 initiative, at a time when students are making a transition from primary to middle school, is not ideal. The impact of ICT implementations in transition years could well be a fruitful area for further research.

Teaching and learning interactions are influenced by a complex mix of psychological and sociocultural factors, in addition to physical and temporal considerations (Hattie & Yates, 2014). It is, therefore, difficult to untangle the impact of a mobile learning initiative from the range of other influences on student learning, particularly when approaches to integrating mobile learning vary from teacher to teacher. For example, it could be that teaching strategies in Grammar and punctuation Years Seven to Nine did not emphasise the use of mobile learning in the classroom. Therefore, inferences about the impact of the 1:1 implementation should be made cautiously. The *way* in which mobile devices are implemented is an important question for future research. This insight was noted by Weston and Bain (2010) in their review of realising the advantages of 1:1 computing. More research, drilling down into the detail, is clearly required to give enhanced texture to studies that seek to link student performance with ICT initiatives.

The mobile learning initiative at the School was implemented to provide students with access to digital learning experiences that mirrored societal trends in the use of ICT. NAPLAN testing tends to ignore key generic and digital literacy skills such as the ability to access and synthesise online information, problem-solving skills, communication skills and ICT capabilities (Grimes & Warschauer, 2008). According to Holcomb (2009, p. 54), ICT skills "do not necessarily align with today's standardised assessments." Therefore, the use of standardised tests in isolation to monitor school improvement in schools with mobile learning programs is problematic. High stakes testing is often conducted in environments where test scores are tied to funding models. While standardised testing in OECD countries is commonplace, Morris (2011, p. 21) discussed some of its associated concerns:

> … there are a number of limitations to standardized tests which weaken the capacity to achieve their purpose. Primarily, standardized tests are limited in scope both in terms of the breadth of their reach and in terms of their depth of assessment.

The literature suggests that the evaluation of mobile learning initiatives with a sole focus on standardised testing results is limited and so researchers continue to search for accurate measures of student achievement in schools with such programs. While standardised testing might be a crude instrument, it nevertheless plays an important role in measuring student improvement in key learning areas because of the associated reliability of the assessment (Suhr, Hernandez, Grimes & Warschauer, 2010; Perso, 2011).

There may well have been benefits of the mobile learning initiative that are currently not measured through standardised testing. Certainly, Newhouse (2014) found that the integration of ICT resulted in benefits that transcended those that might be captured in the formal curriculum. The benefits of mobile learning as a mechanism for enhancing key generic and digital literacies could be the subject of future research into the broader impact of mobile technologies on student learning.

Some of the limitations of the research should be acknowledged. The research was conducted in one single-gender school in one state in Australia. The research was, therefore, based on a relatively small scale single case. Further, the implementation of mobile learning initiative was embryonic and the way in which students and teachers used these devices evolved rapidly over the period of the research. It should also be noted that the purpose of the NAPLAN program is to identify regions and schools that have the greatest need for additional resources, rather than small-scale improvement initiatives such as was the subject of the research. In saying this, the use of NAPLAN data to inform debate around a school improvement initiative was certainly worthwhile. Recently the Australian Curriculum Assessment and Reporting Authority (ACARA) has announced that NAPLAN testing will move from the conventional pen and paper method to an online assessment in 2019 (ACARA, 2016b). If, as Biggs and Tang (2011) suggest, assessment drives learning then online NAPLAN testing may well be a catalyst for more extensive use of ICT for learning.

Conclusion

This paper has sought to provide insights into the extent to which a mobile learning initiative has improved literacy and numeracy outcomes. Ultimately, the paper has addressed the targeted research question: What educational impact, if any, did the mobile learning initiative have on literacy and numeracy outcomes? Focusing on two cohorts, the paper has facilitated a comparison between junior and middle school experiences of the 1:1 initiative with respect to literacy and numeracy outcomes.

Analysis of literacy and numeracy outcomes for cohorts A and B was multi-faceted and considered how each cohort performed over time:

- In pre- and post-mobile learning implementation;
- In comparison to other cohorts at the School; and
- In comparison to national benchmarks.

These comparisons involved disaggregated data (for each of the five domains). The comparisons also included two approaches in which to gauge the overall performance of the cohort mean scores over time. The gains achieved by Cohort B were significantly smaller than those achieved by the 2008-2010 (Years Seven to Nine) School pre-mobile learning cohort, in Grammar and punctuation (ANOVA, $p < 0.01$). In contrast, Cohort A achieved noteworthy gains between 2010 and 2012 (Years Five to Seven) in all domains except Reading.

As mentioned above, these results should be treated with some caution as the level of use of mobile devices varied between subjects and the overall aim of NAPLAN is to inform macro- rather than micro-level change initiatives. Therefore, correlating the data with increases to learning is challenging and underlines the need to prudently understand the contexts and nuances of specific cohorts in terms of performance. Also, due to the limited timeframe of the study, a more relevant longitudinal timeframe of a decade might offer more conclusive findings. The study was set in one school in one socio-cultural setting in one state. The implementation was focused on one type of device. Generalisations to other contexts should be made with caution. The implementation of mobile learning approaches in the two cohorts was variable across NAPLAN areas, and therefore it is difficult to draw any inferences from the data without complimentary, in-depth qualitative data. Mixed methods approaches have proven fruitful in providing a breadth and depth of data which have led to more sophisticated understandings of ICT interventions. Finally, the concern or blame expressed by some members of the education community about declining NAPLAN scores allegedly due to the use of mobile devices for learning appears to be more speculative than proven.

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