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Evaluation Protocol
QuickSmart Numeracy – A one-to-one Maths program for Year 4 and 8 students

15 November 2016

Evaluators

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Evaluation Summary	
Year levels	Year 4 and Year 8
Number of students	274
Number of schools	24
Design	Mixed method Cluster randomised controlled trial
Primary Outcome	To determine the effectiveness of the QuickSmart Numeracy program on the mathematics achievement of low-achieving Year 4 and Year 8 students.

Contents

Background

Intervention

QuickSmart Numeracy is an intensive 30-week one-to-one tutoring intervention to increase fluency and automaticity in mathematics for students performing in the bottom third of their national cohort in mathematics. The QuickSmart program withdraws students in pairs from class for three 30-minute lessons a week, delivered by a trained school staff member (instructor), typically a teacher assistant. The program runs for 30 weeks, excluding a two-week setup and close-down period. QuickSmart lessons usually occur in a dedicated room within the school, with access to computers.

Lesson structure

Each lesson begins with a review of the focus facts, starting with those already known, and moving on to those yet to be remembered. Instructor-led discussion and questioning about the relationship between number facts and ways to recall them merge into simple mathematics fact practice activities. Flashcards and timed performance activities assist students to develop automatic recall. The timed performance activities use the OZCASS program, which provides ongoing data to students and the instructor about the student's improvement in speed and accuracy. In the last part of the lesson, students practise their skills independently on carefully selected worksheets that are closely related to the lesson content.

Resources

Lesson delivery is supported by a package of resources including a full Flash Card Kit, Teacher Manual, an extensive Resource Folder, Games Pack and a three-year license for a program referred to as OZCASS. OZCASS works on PC computers and provides time and accuracy scores on randomly generated basic mathematics operations. Schools involved also have access to a private area on the internet that contains large numbers of useful teaching materials, many developed by QuickSmart Schools.

Professional Learning

To ensure the materials are used as intended, QuickSmart trains instructors from schools, usually teacher assistants (sometimes a school executive or teacher), in a Professional Learning (PL) program. QuickSmart PL has a developmental perspective, is spread over a number of years and has a strong practical focus on cognition and neuroscience research. There are three two-day workshops in the first year a school runs QuickSmart; three one-day workshops in the second year; and an optional single one-day workshop for the third and subsequent years. These workshops typically occur at a central location, with instructors from many schools attending.

Data and monitoring student progress

Before the 30-week intervention, there is a two-week set-up phase. In this setup phase, students are introduced to the program and their role. During this time, delivery staff use OZCASS to collect pre-intervention data in terms of speed and accuracy on basic numeric skills, as well as performance on an independent test (of age-appropriate material but not mathematics topics specifically part of the intervention). These data provide base-line information to guide the instructor on where instruction might most profitably begin. Further data is collected in each lesson to give students and the instructor information about the student's improvement in speed and accuracy of basic mathematics facts.

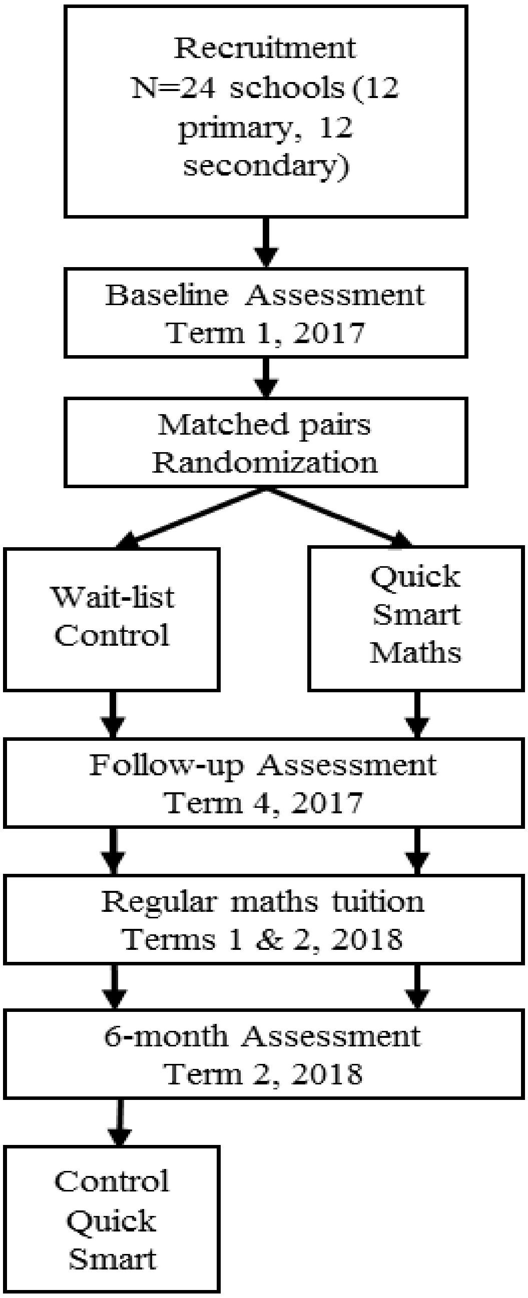
Following the 30 weeks of instruction, students are re-tested to obtain post- intervention data. The style and substance of the testing is equivalent to what occurred previously.

Significance

QuickSmart Numeracy is designed to offer Year 4 to 9 students who are performing in the bottom 30% of the achievement spectrum a second chance. The aim is for students experiencing significant and sustained learning difficulties to become active and engaged learners.

Students who experience ongoing failure in upper-primary and lower-secondary school face a myriad of difficulties in pursuing post-school options and contributing to society through employment and active citizenship. Those who exhibit consistent weaknesses in basic skills, such as the recall of number facts, are particularly vulnerable. These students are most often caught in a cycle of continued failure. National data show that it is particularly difficult to bring about sustainable change within the usual classroom environments for students who, by Year 4, are persistently at or below national benchmarks. Also, Australia's declining performance in mathematics on international assessments such as PISA, and the widening gaps in mathematics performance between advantaged and disadvantaged Australian students, means that there is considerable need to identify programs and approaches that may be effective in improving achievement of low performers.

Since 2001 over 1,200 schools from across the country have used the QuickSmart program. In those years, SiMERR has evaluated QuickSmart using a comparison student design, using a small sample of average-achieving students, selected by the school, as the comparison group. Results using this design have shown high effect sizes for the QuickSmart students. Having an independent, randomised controlled trial of QuickSmart would help the many schools and systems that currently use QuickSmart to know whether the positive results are maintained under a rigorous scrutiny.



Methods

This mixed methods project offers a systematic and comprehensive approach to understanding the effects of the proposed intervention. The proposed evaluation design is a cluster randomised controlled trial involving parallel comparison of matched pairs within the same class. This design offers the greatest control over potential bias, and gives the strongest level of evidence in the determination of the effectiveness of the QuickSmart Numeracy program.

Research questions

1. What is the impact of QuickSmart on student mathematics achievement?
2. What is the impact of QuickSmart on student self-efficacy and engagement in relation to mathematics?
3. What is the impact of QuickSmart on student experience within the classroom and the broader school context? and
4. What is the cost per student of the QuickSmart program?

Evaluation design

Recruitment

The plan is to recruit schools with an ICSEA of under 1000, where possible, from Sydney Catholic Schools (SCS).

The evaluation will consist of two separate cohorts drawn from 12 primary and 12 secondary schools respectively. This design is based on an approximation of 2-3 maths classes per school, with between 8 and 12 students per class identified to participate in the program and evaluation.

Participant eligibility

Students identified in the bottom 30% of the most recent NAPLAN round (Year 3 for Year 4 cohort, Year 7 for Year 8 cohort) are invited to participate by the University of Newcastle research team via the process:

1-SCS to identify the numbers of eligible students enrolled for 2017, and share a list of schools with the numbers eligible (no student identification) with The University of Newcastle (UoN) and University of New England (UNE) research teams.

2-Suitable schools (appropriate numbers to maintain clustering and sample size) will be selected and invited to an invitation presentation with SGS, UNE, UoN present.
3-Schools identified by UoN are invited by UNE and SCS, with schools passing recruitment documents to the students identified by SCS.

Sample size calculations

The primary intervention outcome is student achievement in mathematics, targeting students from schools with an ICSEA of below 1000, where possible. Secondary outcomes include student self-efficacy, engagement, and self-regulation and teacher self-efficacy and expectancy outcome. The calculated sample size includes considerations of statistical power and access to a convenient sample indicated by the intervention research team.
The sample size calculation is based on a three-step process:

1. Calculation for a linear models approach (repeat measures ANOVA)
   Assumptions: Effect= 0.15 (moderate), Alpha = 0.05, Correlation among measures= 0.5, Power=.80
   Note. We used a low correlation among repeated measures because in taking the lowest 30% of NAPLAN achievement, there will be minimal variation within the group which will most likely produce low pre-post correlation due to the lack of variance available in this group
   Sample = 90

2. Adjustment for clustering
   Assumptions: rho(w) = 0.05 (correlation coefficient for within cluster variation), subjects per cluster (class) = 10
   Note. The more students per class in the sample, the more the sample has to be inflated. More clusters with fewer students is a stronger design. This is because there is typically more variation within a group than between groups.
   Design effect (cluster inflation) = 1.45

3. Attrition
   Given this is a school program, attrition is likely to be low
   Attrition = 5%

   Total sample per year level:
   - 90 x 1.45 (clustering)= 131
   - 131 x 1.05 (attrition)= 137

Total sample per year group = 137 students
Total sample= 274 students

Baseline measures

Students undertake the *Progressive Achievement Test - Maths* (PAT-M) as the baseline measure of mathematics achievement (primary outcome). As the test is undertaken at the commencement of a new school year, students undertake the PAT-M at the level of the year level completed in 2016 (Year 3 and 7 PAT-M for Year 4 and Year 8 respectively). These online tests will be administered by the University of Newcastle and take place in term 1, 2017 for all participating students.

All participating students will be asked to take the Efficacy and Engagement with Mathematics PISA survey (secondary outcome I), and a randomly selected subgroup will,be invited to be interviewed about their attitudes to and experiences of mathematics learning (secondary outcome II). This will be administered by the University of Newcastle during Term 1, 2017.

Note. See Outcome Measures below for further details.
Note. See timeline for further detail.

Randomisation

Randomisation occurs after baseline assessment. Participants, selected from the bottom 30% of their most recent NAPLAN result. To account for potential variation in PAT-M scores within classes, pair blocks are formed by stratification by gender and PAT-M score (below and above the 50th percentile of the group). Participants within a pair are randomised to the intervention or 18-month wait-list control via a coin toss by an independent third party (statistician).

Dr Andrew Miller will conduct the pairing of participants within clusters, and keep password-protected copies of pairings prior to randomization by the third party. Andrew Miller will store password-protected copies of the final randomization list, and provide the list of intervention participants within each cluster to the intervention implementation team.

Note. This randomisation process is designed to reduce regression to the mean (RTM) during analysis. Random allocation to comparison groups ensures the responses from all groups are equally affected by RTM. With two groups, placebo and treatment, the mean change in the placebo group provides an estimate of the change caused by RTM (plus any placebo effect). The difference between the mean change in the treatment group and the mean change in the placebo group is then the estimate of the treatment effect after adjusting for RTM[1].

QuickSmart Numeracy intervention

Students in the intervention condition undertake the QuickSmart Numeracy program for the remainder of the academic year, with the control condition receiving the regularly programmed maths tuition in class.

During the intervention, a random sample of students in the intervention condition will be invited to participate in regular interviews to explore their experiences of the QuickSmart Numeracy program. Regular observations of the QuickSmart process will also take place to ensure fidelity and adherence to process.

Outcome measures

Student Measures

Achievement measures

- **Progressive Achievement Test – Mathematics (PAT-M)**

The primary intervention outcome will be measured with the Australian Council for Educational Research's, PAT-M. The PAT-Mis a rigorously tested measure of mathematics achievement that is well suited for evaluation of this project because each year level test is designed to be developmentally appropriate (e.g., Year 4; Year 8), and yet scaled so that direct comparisons can be made between year levels and growth can be tracked across year levels. This type of measurement flexibility aligns closely with the analytical procedures of the study design. As participants undertake assessment using multiple year levels of the PAT-M measure, the age-standardised scaled score is used as the variable of analysis. PAT-M will be administered online by the University of Newcastle researchers in Term 1, 2017 and Term 2, 2018.

- **NAPLAN**

For the Year 4 student cohort, Year 3 (2016) and Year 5 (2018) NAPLAN-Numeracy data is sought for analysis of progressive numeracy achievement. The waitlist control group will receive the intervention after NAPLAN 2018. The evaluation team will request the relevant

[1] Feria, J., Valke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. Learning and Individual Differences, 19, 499-505.

Year 3 and Year 5 NAPLAN results from all students in the classes that participate in the evaluation. These data will be used as an additional measure to track the learning trajectories of all students in the cohort.

For the Year 8 student cohort, Year 7 (2016) and Year 9 (2018) NAPLAN-Numeracy data is sought for analysis of progressive numeracy achievement. The waitlist control group will receive the intervention after NAPLAN 2018. The evaluation team will request the relevant Year 7 and Year 9 NAPLAN results from all students in the classes that participate in the evaluation. These data will be used as an additional measure to track the learning trajectories of all students in the cohort.

Cognitive and affective measures

- **Efficacy and engagement with mathematics PISA scales**

Student self-efficacy and engagement in mathematics will also be measured because they represent important learning-process outcomes and act as cognitive mechanisms that link quality learning environments to achievement. Self-efficacy and engagement will be measured using instruments developed for the Programme for International Assessment (PISA). The PISA math self-efficacy scale is comprised of eight items.
Previous research has demonstrated its ability to produce valid and internally consistent scores in a large sample of secondary students[2]. The PISA interest and enjoyment in mathematics scale, consisting of four items, will be used as a measure of student engagement. Previous PISA technical reports and research from which the questions were based highlight both valid and internally consistent scores[3]. PISA will be administered online by the University of Newcastle during Term 1, 2017 and Term 2, 2018.

- **Interviews**

Interviews with a random sample of students will be used to examine their experiences of the QuickSmart Numeracy program. Two students from two schools for each cohort along with their matched pairs (n = 16 students) will be randomly selected and invited to participate in pre-intervention and post-intervention interviews to explore their opinions about mathematics and their achievement in mathematics. These interviews will be conducted by Dr Jess Harris (UoN).

Further interviews with students in the intervention condition of the evaluation will take place alongside observations in weeks 8, 16, and 24 of the QuickSmart Numeracy program. The

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[2] Feria, J., Valke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. Learning and Individual Differences, 19, 499-505.
[3] Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Changes in children's competence beliefs and subjective task values across the elementary school years: A three-year study. Journal of Educational Psychology, 89, 451-469.

regular interviews with students participating in the program will explore a range of areas, including:

- Student experiences of learning mathematics;
- Student perceptions of being asked to participate in the program;
- Student perceptions of participating in the program;
- Student reports of the social impact of being withdrawn from class;
- Student experiences of the program (what happens in the program; does the process/ interaction change depending on who is running the program?); and,
- Whether students' experiences of the program change over time.

- **Observations**

Regular observations will be used as part of an ethnographic analysis of the academic and social impact of the QuickSmart Numeracy program on students' experience of mathematics. These observations will be used to explore the areas outlined above.

Observations of four students from each cohort participating in QuickSmart Numeracy will be undertaken in weeks 8, 16, and 24 of the program. These observations will serve as qualitative measures to understand students' experiences of the program and contextualise the interview data. Observations will be undertaken by Dr Jess Harris (UoN).

QuickSmart instructor and classroom teacher measures

- **Mathematics Teaching Efficacy Beliefs scale**

QuickSmart Numeracy program instructors and classroom teachers whose students participate in the program will be asked to complete a survey measuring efficacy and teaching outcome expectancy with mathematics. These two variables will be utilised in order to provide a measure of teachers' and program instructors' confidence in delivering mathematics to students. The two measures will be determined through the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). This instrument contains 21 questions, is widely used for this purpose with in-service and pre-service teachers, and has proven validity[4].

- **Interviews with a random subsample of teachers**

Post-intervention interviews will be conducted with 8 classroom teachers, including 4 from each cohort. These interviews will gather teachers' perceptions of:

- outcomes of the program for their students;
- the social impact on students of being involved in the program; and
- whether their students' experiences of the program changed over time.

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[4] Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. School Science and Mathematics, 100(4), 194-202.

- **Interviews with a random subsample of QuickSmart instructors**

Interviews with QuickSmart instructors delivering the program to the random subsample of students involved in the interview phase (n=4) will be used to examine key barriers and enablers to their effective delivery of the QuickSmart program. These interviews will be conducted by Dr Jess Harris (UoN).

Analysis plan

Statistical analyses will be completed using PASW Statistics 21 (SPSS Inc. Chicago, IL) software. Alpha levels are set at $p < 0.05$. Independent samples t-tests will be used to compare differences between groups at baseline. Linear mixed models will be fitted to compare intervention and control groups for continuous variables. Group (intervention or control), time (baseline and follow-up) and group-by-time interaction will be assessed as fixed effects within the model. Potential gender effects will be explored using a group-by-time-by-gender interaction term in the mixed model. To examine the effect of the teacher, clustering effects at the class level will be examined as a random intercept within the model. Differences of means and 95% confidence intervals (CIs) are determined using the linear mixed models. Analyses include all randomized participants. Hedges g is used to determine effect sizes of the change in mean for each group relative to the baseline value (effect of intervention on the change score).

Process evaluation

Process evaluation will be conducted at intervals specified in the timeline below and will assess the following:

- **Tracking program instructors' adherence to QuickSmart protocols and student attendance**

Program instructors for each of the QuickSmart Numeracy sessions are asked to fill out a brief online fidelity checklist. This checklist will be developed in conjunction with the program developers in order to ensure that the program is delivered as intended. The survey will also ask instructors to report on student attendance to sessions to determine overall exposure to the program (this includes missed sessions). Student exposure (proportion of sessions attended) and program adherence (average proportion of checklist items) will be reported.

- **Random observations**

To support the process evaluation a subsample of 20% of instructors in the intervention condition will be randomly selected for observation once in order to check protocol against the fidelity checklist. This will provide measures of consistency in program delivery and levels of student engagement across instructors. To ensure independence of reliable measures observations will be compared to the instructors' checklist to ensure fidelity.

Note. Wait-list control group should not receive intervention until final data collection for sustainability measures is complete (i.e. May/June 2018).

Cost data

Analysis of cost per student will include:

- QuickSmart license cost - 3-year involvement
- QuickSmart instructor cost
- Initial training cost (Instructor release and training specific costs)

Analysis of cost per student will NOT include:

- Administration costs from the intervention team during this study

Note. The above calculation is for three years of QuickSmart involvement, and will be calculated for various group sizes participating in QuickSmart per year (E.g. 10 - 20 students, 20 - 30 student and 30 - 40 students per year).

Ethics and registration

This evaluation will be assessed and approved by the Human Research Ethics Committee at the University of Newcastle and the SCS.

To participate in this evaluation, full informed consent will be required from parents in addition to student assent to involvement.

This trial will be registered with the Australian and New Zealand Clinical trials registry.

Risks

Category	Risk	Likelihood	Impact	Management strategies
Staff	Possible loss of key staff (including proposed leave or secondment arrangements, other work commitments)	Low	Low	CIs have a strong record of success in managing projects of this scale. There are no foreseen staffing issues that would have a negative impact within the project timeframes. In terms of research environment, there is additional depth of support as a project under the Teachers and Teaching Research Centre.

Category	Risk	Likelihood	Impact	Management strategies
Project management & coordination	Lack of communication across project team and with SiMERR and/or SVA	Low	Low	Project management will be strong with trained and highly experienced PMs, systematic approaches to project management structures, and researchers with a strong record of success. There is a low risk of issues in communication and conduct of tasks. While the project is challenging given scope and complexity, we have the demonstrated capacity to meet these challenges.
Methodology	Analysis and reporting of quantitative and qualitative data	Low	Low	The project will use the standards and quality assurance measures developed across a range of projects to verify data and analytical processes in accordance with the University's policy on data management and security. Technical resources and expertise is in place with dedicated workspaces, with CIs, statisticians and qualitative analysts available with capacity to take on this work. The resources and software tools required to conduct the proposed analyses are already available. There are no foreseeable disruptions in carrying out this work.
Adherence to timelines	Meeting timelines	Low	Low	The risk of overrunning timelines is recognised but assessed as minimal. Given CIs' proven ability to plan, implement and complete research and the support of highly experienced PMs, the risk of overrunning timelines is minimal. The other members of the project team will report to and meet with CIs on a weekly basis from project initiation to ensure effective management and timely completion of milestones.

References

1. Feria, J., Valke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. Learning and Individual Differences, 19, 499-505.
2. Feria, J., Valke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. Learning and Individual Differences, 19, 499-505.
3. Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Changes in children's competence beliefs and subjective task values across the elementary school years: A three-year study. Journal of Educational Psychology, 89, 451-469.
4. Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. School Science and Mathematics, 100(4), 194-202.