Schema-based instruction and maths problem solving

Macquarie University Special Education Centre (MUSEC)

Final Report

Schema-Based Instruction and Maths Problem Solving

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Executive Summary

Macquarie University Special Education Centre (MUSEC) is a special school for students from Kindergarten to Year 6, all of whom have a diagnosis of autism (ASD) and/or mild or moderate intellectual disability (ID) and/or language disability. Every student at MUSEC has an Individual Education Plan (IEP) that includes, among other things, a focus on numeracy skills. During 2016, all teachers at MUSEC took part in a professional learning exercise to examine and revise numeracy learning goals and teaching strategies contained in the MUSEC, IEP database. Through this whole school project, *Working Mathematically*, and more specifically solving maths word problems, was identified as an area of need, both in terms of students' learning outcomes and teacher practice.

For decades the field of special education has struggled to bridge the research to practice gap. While there is ample evidence from research of effective strategies for students with special needs, these strategies are not routinely implemented in schools in ways that yield positive results for students. In recent years, the field of special education has turned its focus to implementation science. The MUSEC, two-stage school-based research project (SBRP), applied principles of implementation science to introduce schema-based instruction (SBI), an evidence-based practice (EBP) for teaching maths problem solving to students with special needs, across the school.

Stage 1 of the project involved two 'small n' studies (Study A and Study B) that examined the efficacy of SBI as an intervention to support maths problem solving. In Stage 1 students were taught to use a graphic organiser (or schema) displayed on an iPad or Smart Board, a mnemonic (FOCUS) and a checklist that contained visual prompts for each step undertaken, to solve a word problem. Study A comprised a multiple probe across participants design and Study B comprised a pre- and post-test small group design. In both Stage 1 studies, word problem solving was measured as:

1. Number of independently performed problem solving steps measured continuously through baseline and intervention
2. Number of accurately solved problems measured continuously through baseline and intervention

Post intervention all students improved their accuracy of solving addition and subtraction '*change*' word problems and in the number of problem-solving steps used independently. When assessed on their knowledge of the step required for each letter of FOCUS, 5 of 6 (83%) students could articulate each step. Students reported that they enjoyed working on the iPads and that they felt they could use the strategy independently.

Stage 2 of the project introduced SBI across the school. In Stage 2, using an action research design that allowed for adjustments and modification to be made over the year-long study, two cohorts of teachers were trained and supported in six-week learning cycles to implement SBI in their classrooms. To evaluate the effectiveness of the implementation approach, both student and teacher data were collected. In Stage 2 students improved in the number of word problems they answered correctly and in the number of problem-solving steps completed independently. Teachers generally implemented SBI with fidelity. Teachers reported an increase in the amount of time spent teaching problem solving, increased confidence in teaching problem solving and improved perceptions of students' ability to solve word problems. Teachers reported preferring coaching and small group meetings as methods to receive professional development.

These findings are in line with research that shows student learning can improve when teacher professional development is provided over an extended period of time, actively involves teachers, and utilises a variety of learning methods in classroom contexts. Further research is needed to evaluate whether these gains in teacher instruction and student achievement can be maintained over time once the professional development is completed. The significance of this school-based research project is that it provides a model of how teachers can translate research to practice to improve student learning in a school setting. It also adds to the evidence that SBI is an effective strategy to teach mathematics problem solving to students with additional needs.

Introduction

In Australian schools, teachers are charged with the responsibility of providing high quality instruction to all students, regardless of their ability or background. The overarching aim of mathematics instruction is to ensure that all students develop the knowledge and skills they need to use mathematics confidently, that they recognise and understand the role of mathematics in the world and that they have the disposition and capacity to use mathematical knowledge and skills purposefully (ACARA, 2012). Consistent with this is the view that successful mathematics problem solving applied to everyday life should be a focus of instruction for all students.

Macquarie University Special Education Centre (MUSEC) is a Kindergarten to Year 6 special school located on the campus of Macquarie University. All 44 students attending the school have a diagnosis of autism (ASD) and/or mild or moderate intellectual disability (ID) and/or language disability. The school comprises four classes of either 10 or 12 students. Each class is staffed by two teachers with postgraduate qualifications in special education and a classroom assistant. The school functions as a research site, a model of evidence-based practice and a practicum site for post graduate special education students enrolled at Macquarie University. All students at MUSEC have an Individual Education Plan (IEP) that includes numeracy goals.

During 2016 teachers at MUSEC took part in a professional learning exercise to examine and revise numeracy learning goals and teaching strategies contained in the MUSEC, IEP database. Through this whole school project, *Working Mathematically*, and more specifically solving maths word problems, was identified as an area of need, both in terms of students' learning outcomes and teacher practice. Schema-based instruction (SBI) had been identified as an evidence-based practice (EBP) Jitendra, 2007) and prior to 2017, SBI had been introduced by one MUSEC teacher to teach *'change'* problems to some students in Years 4-6. The SBI program (Jitendra, 2007) used by this teacher had been developed to support middle school students with learning difficulties rather than students with ASD and/or ID. During 2016 Dr Mills, a MUSEC master teacher, attended a Council for Exceptional Children conference session on SBI. In this session Dr Alicia Saunders presented research into the use of a model of SBI, termed modified schema-based instruction (MSBI), with primary school students with ASD and moderate ID. With the teachers having identified maths word problems as an area of need, Dr Saunders' work had particular relevance to the MUSEC context.

SBI has a focus on conceptual understanding and comprehension to assist students to understand the underlying structure of the problem at hand. The most common word problem structures in primary school and in the SBI literature are *change, group,* and *compare*. *Change* problems involve joining or separating sets. *Group* problems are part-part-whole problems. *Compare* problems use the words more/less/fewer and involve comparison of quantity. Each structure has three numbers, any one of which can be the unknown in a story situation. SBI teaches students the semantic structure of each type of word problem and the quantitative relations or actions between the sets (Jitendra, 2007; Spooner, Saunders, Root & Brosh, 2017).

The MUSEC two-year SBRP examined the impact of SBI on a small population of primary aged students with ASD and/or ID and the translation of this evidence-based strategy into teacher practice across the school. Stage 1 of the project, conducted during 2017, involved two 'small n' studies (Study A and Study B) examining the efficacy of SBI as an intervention to support maths problem solving. In Stage 1 the focus of instruction was *change* problems. Stage 2 of the project, conducted during 2018, applied principles of implementation science to introduce SBI across the school. In Stage 2 the focus was *group* problems. This report has been structured to provide a detailed account of the implementation of each stage of the project.

Literature Review

Schema-Based Instruction

Traditionally much of the emphasis of mathematics teaching in special education settings and for students with mathematics difficulties (MD) has been on computational skills with the bulk of research into effective mathematics instruction for low achieving students having a focus on computational skills and procedures rather than problem solving (Root, Browder, Saunders & Lo, 2016). It is generally accepted that students with MD have difficulty solving word problems (Rockwell, Griffin & Jones, 2011). For students with ID and ASD the language demands of word problems, and the multistep processes required to reach a solution, present particular difficulties (King, Lemons & Davidson, 2016). Linguistic difficulties may mean that sentence structure, sentence complexity, vocabulary and the order that key information appears in the problem present challenges. Poor executive functioning may result in difficulties with planning, organising information and deciding on which strategies to use. Problems with working memory, attention, background knowledge along with early numeracy deficits and lack of self-regulation, are further characteristics that may impede a student's capacity to solve word problems (Geary, Hoard, Byrd-Craven, Nugent & Numtee, 2007; Geary, 2011). Such difficulties all have an impact on students' ability to form problem representations, and hence accurately solve word problems (Peltier & Vannest, 2018; Jitendra, 2007).

When *Working Mathematically* students, among other things, connect mathematical concepts and choose and apply problem-solving skills and mathematical techniques (NSW Education Standards Authority, 2012). In the special education literature, performance on word problems typically serves as a measure of a student's ability to apply mathematics to real life situations (Peltier & Vennest, 2017). Based on indicators suggested by Horner et al. (2005), schema instruction has been recognised as an evidence-based practice (EBP). In recent years, schema instruction applied in the area of mathematics problem solving has taken on a number of different forms. Powell (2011) classified two approaches: schema-based and schema broadening. Root et al. (2017) refer to their model for teaching mathematical problem solving to students with severe disabilities as modified schema-based instruction (MSBI).

Spooner et al. (2017) identify four, key 'actions' for effective implementation of MSBI for students with disabilities. The first of these is *Create Access to the Problem*, achieved through an interactive 'read aloud' and by ensuring the problem content is meaningful and concrete. Spooner et al. (2017) suggest writing multiple problems related to students' interests. Second is *Conceptually Comprehend the Problem*, achieved by mapping the story grammar using graphic organisers (schema) and manipulatives. Third is *Procedurally Solve the Problem*, achieved by applying the steps of a task analysis (using a checklist). Fourth is *Generalise Multiple Ways*, achieved by solving problems in different contexts such as using the SMART Board or video modelling. All aspects of instruction need to reflect evidence-based strategies for teaching students with MD.

Throughout the special education mathematics teaching literature, it is recognised that effective teaching of mathematics involves explicit teaching of concepts, procedures and cognitive strategies (Gersten, Chard, Jayanthi, Baker, Morphy & Flojo, 2009; Ketterlin-Geller, Chard & Fien, 2008). Practices common to reviews of effective mathematics instruction include: clear goals with explicit performance criteria; explicit and systematic instruction; verbalisation (including 'think aloud'); visual representation (teaching from concrete to abstract representations); careful selection of the range and sequence of examples; instruction in problem solving strategies; and frequent formative assessment and feedback. For students with significant disabilities, instruction typically starts with a model-lead-test approach.

SBI that incorporates the features of instruction described above has been demonstrated to be an effective problem-solving intervention for middle school students identified with MD (Jitendra, DiPipi & Perron-Jones, 2002; Jitendra, George, Sood & Price, 2009; Montague, Warger & Morgan, 2000; Xin, Jitendra & Deatline-Buchman, 2005) and examination of recent mathematics teaching literature reveals a growing body of research that supports SBI as an effective problem-solving intervention for primary school students (Peltier & Vannest, 2017; Peltier, Vannest & Marbach, 2018). SBI, in the form of MSBI, has been demonstrated to be an effective intervention for primary school students with ID and/or ASD (Browder, Spooner, Lo Saunders, Root et al., 2018; Levingston, Neef & Cihon, 2009; Rockwell, Griffin & Jones, 2011; Jitendra et al., 2015; Root, Browder, Saunders & Lo, 2016; Spooner, Saunders, Root & Brosh, 2017). Within SBI research that has a focus on students with disability, levels of prompting and error correction are tightly controlled and task analysis steps are presented as a problem-solving checklist with pictures and text. Pre-teaching of prerequisite skills, teaching individual steps through massed trials, modifying materials and considering criteria for progression are all adjustments to be considered on the basis of individual student need (Spooner et al. 2017).

Effective Adult Learning

With evidence to support the use of SBI for students with disabilities, the question then becomes how to effectively change teacher practice in a way that has a positive impact on student achievement. In a meta-analysis of the impact of professional learning activities on student achievement, Yoon and his colleagues (2007) found that interventions that included more than 14 hours of professional development had a significant effect on student achievement. On the other hand, when less than 14 hours of professional development was provided, there was no effect on student achievement. Furthermore, all but one of the studies in the meta-analysis included a workshop with follow-up support. (The one study that did not include follow-up support was a four-week summer course.) Overall, the authors concluded that “average control group students would have increased their achievement by 21 percentile points if their teacher had received substantial professional development (p iii),” pointing to the critical role high-quality professional development plays in improving student learning.

In another meta-analysis, Dunst, Trivette and Hamby (2010) looked at which professional development approaches were most effective for improving teacher knowledge, skills, attitudes and self-efficacy. Of the four professional development approaches studied, coaching had the highest effect size (d = 0.91). The authors looked further at which adult learning methods had the biggest effects. Examples of adult learning methods include lectures, role playing, real life applications and self-assessments. They found that the components that were more learner-centred (e.g., problem solving tasks, review experiences and make changes) had bigger effects than instructor-centred tasks (e.g., dramatic readings, instructional videos). Additionally, the more adult learning methods that were included in the professional development, the more effective it was. Smaller group sizes (i.e., less than 30 participants) and more training time also resulted in more positive outcomes.

Fullan and Hargreaves (2015) add to this knowledge the importance of collective learning in making long-lasting changes that improve student learning. They emphasise the importance of structures like shared work and peer feedback so that gains are not limited to individual teachers. Specifically, they recommend group professional learning activities like extended institutes, action research and instructional coaching, to name a few examples. This collective teacher learning leads to a shared sense of accountability for student learning, which, in turn, can lead to sustained improvement.

Aims and Research Questions

The aim of this research project was to inform the professional practice of teachers in both regular inclusive classrooms and special education settings thus developing their capacity to: *Differentiate teaching to meet the specific learning needs of students across the full range of abilities* (Teaching Standard 1.5, AITSL).

The model of SBI adopted in the current project contains some, but not all, elements of Root et al.’s (2016) MSBI and thus in this report, is referred to as SBI. Stage 1 of the project was designed to confirm that SBI was an effective intervention for students at

MUSEC who had a diagnosis of ASD and/or ID and/or language disability or communication deficit. To that end our research questions were:

1. Can primary age students with ASD and ID correctly solve addition and subtraction word problems following schema-based instruction?
2. Can students independently follow the problem-solving steps?
3. Do students enjoy schema-based instruction and find it useful?

Stage 2 of the study shifted the focus to school-wide implementation. This implementation involved both adjusting materials to suit a wider student population and training teachers to provide SBI. To that end, our research questions were:

1. What adjustments and modifications to teaching materials are required to meet the needs of all students at MUSEC?
2. Can student accurately solve group word problems? Can they independently follow the FOCUS steps to solve group word problems?
3. Can teachers implement SBI with a high degree of fidelity?
4. Do teachers find the strategy easy to implement and effective for student learning?
5. Which professional development approaches were most highly valued by teachers?

Stage 1 Methods, Data Collection and Results

Design

Study A was single-subject, multiple baseline probe design that meets the requirements of high quality single subject research (Horner et al., 2005). In Study A baseline performance for each of 3 participants was measured over 5 sessions. The student with the most stable performance at baseline received the intervention first while the other 2 participants remained in the baseline condition. Study B was a class-based project in which pre- and post-test, generalisation and maintenance data was collected for students who received instruction in a small group of 3 students.

Data Collection

***Student Data*.** In Study A, a minimum of five baseline testing probes were collected before instruction began. For each probe 8 problems (Appendix A) were administered with data recorded on total number of correct answers and total number of problem-solving steps completed. During the intervention phase, weekly testing probes of 8 problems were administered with data following the same format as the baseline probes. Five post-test probes were administered when instruction was completed, and a generalisation probe that applied the FOCUS strategy to solve problems with bigger numbers was administered the day after the last post-test probe. Maintenance data for 8 problems were collected at 2 weeks and 6 weeks post-instruction. A social validity questionnaire was also administered to students at post-testing. Participants were asked to rate their agreement with seven statements using a smiley face system from 'not at all' to a 'lot'. They were also asked what the mnemonic FOCUS stood for.

In Study B, five baseline testing probes were collected before instruction began. These were the same testing probes used in Study A, with data recorded on the total number of answers correct and the total number of problem-solving steps completed. During instruction, the instructor collected data on the level of prompting required for students to complete the problems presented during the session. Data were collected for each student solving at least one problem during each session. This was used to determine when students were ready to begin post-testing (i.e., when they needed no or minimal teacher prompts to accurately complete the problems). Five post-test probes were administered when instruction was completed, following the same format as the baseline probes. Generalisation and maintenance data were collected at 2 weeks and 6 weeks post-instruction. Additionally, the same social validity questionnaire as used in Study A was administered to Study B participants at post-testing.

Fidelity of treatment. Video recordings were made of individual and small group lessons. Fidelity of treatment data was collected on the two researchers/teachers. Twenty percent of Study A lessons and 45% of Study B lessons were checked by the project's research assistant and the researcher who had not taught the videoed lesson to evaluate the degree to which the researchers accurately implemented the steps of the intervention.

In Study A the overall fidelity of treatment was 87%. When looking across the 5 steps of instruction the fidelity ranged from 74% to 97%. The step with the lowest fidelity was step 5 in which the student had to practice solving problems using the checklist. The third student did not consistently use the checklist when solving problems. In Study B the overall fidelity was 82% (range 72% to 94% across steps). Again, the lowest fidelity occurred when students were to the checklist to solve problems. The part of step 5 that was omitted was teacher modelling of using the checklist. Instead, in both studies, students were predominantly provided with guided practice.

Intervention Design

Lesson materials. Lesson scripts and materials were developed for *change* word problems. Lesson scripts followed a strategy instruction approach that included the following steps: (1) develop background knowledge, (2) consolidate the problem type, (3) introduce the graphic organiser, (4) introduce FOCUS and use it to solve word problems to find the missing part (i.e., when only 2 parts are known), (5) use FOCUS to solve word problems and (6) independent practice without the graphic organiser and checklist (see Appendices A and B). A prompt level guide and prompt level data collection sheet were also written (Appendices C and D).

The FOCUS checklist provided a task analysis of the problem solving process. (**F** find problem type, **O** organise the information, **C** create number sentence, **U** use the number line, **S** solution.) The level prompting guide provided least to most prompts for each step (Appendix C). Level 1 the teacher gives a reminder, Level 2 the teacher says the step and gives a hint and Level 3 the teacher models required action and the student repeats. The level of prompting required to complete each problem-solving step was recorded during each instructional session. All word problems were *change* problems. In developing the MUSEC FOCUS intervention the researchers made a conscious decision to include problem examples with the missing amount in different positions (e.g. 3 + 6 = x, 3 + x = 9, x + 6 = 9, 9 – 6 = x, 9 – x = 3, x – 6 = 3).

Teaching Procedure. Stage 1 of the project was conducted over 3 school terms. Lessons of 15-20 minutes were delivered in an observation room adjacent to the classroom (Study A) by Dr Howell (School Principal/researcher) or in the Primary 2 classroom (Study B) by Dr Mills (Master Special Educator/researcher), 4 days per week. *Change* problems were the focus of instruction. *Change* problems comprise a beginning quantity, a change of quantity indicated by an action (+ or -) and a resulting end quantity. Students were taught to use a graphic organiser, or schema (Appendix B), and a mnemonic checklist (FOCUS) that contained visual prompts for each step undertaken to solve a word problem (Appendix C). Training sessions followed a model-lead-test format. Consistent with SBI, students were taught to identify key characteristics of the problem to determine problem type. The researchers modelled how to follow the steps of the task analysis and provided guided practice that included systematic prompting (Appendix D). Problem solving using the schema was first modelled on paper then on an iPad (Study A) or SMART Board and iPad (Study B). Teaching scripts developed specifically for the project were used to ensure consistent delivery of the teaching steps and prompt levels. Teachers collected data on the level of prompting students needed for each step of FOCUS (Appendix E). Appendix F contains a sample of the lesson script for change problems and Appendix G contains an outline of each step of the intervention.

Participants

Table 1

Participants in stage 1 studies

Participant	Age	Disability
Study A		
Zoe	8.17	ASD, mild ID, moderate LD, mild CD
Paul	7.33	ASD, mild ID, severe LD, moderate CD
Lisa	6.75	ASD, moderate CD
Study B		
Molly	7.5	ASD, mild CD
George	9.0	ASD, mild CD
Jamie	9.17	ASD, severe LD

Note: ASD=autism spectrum disorder. CD=communication deficit as measured by Vineland II. ID=intellectual disability. LD=language disorder

Enrolment paperwork for all participating students confirmed that they had a diagnosis of ASD. Disability confirmation is a prerequisite for attendance at MUSEC. Students with ASD but no diagnosis of ID or language disability on school intake documents were assessed for communication deficit using the Vineland-II. Participants for Stage 1 were selected on the basis of their ASD, language performance (i.e. language disability or communication deficit) and the set of prerequisite skills that would allow them to successfully calculate correct answers for problems using numbers in the range of 0-10. Prerequisite skills included the ability to: name and write (or select) numerals 0-20; name and write (or select) +, -, = signs; and model addition and subtraction to 10 using concrete materials.

Recruitment

Parents sign a research agreement as part of the MUSEC enrolment procedure. MUSEC has ethics approval from Macquarie University that covers the use of data collected as part of students' educational programs. With maths problem solving appearing in students' IEPs, the SBI intervention was part of each student's maths program. Parents were informed of their child's involvement in the project.

Stage 1 Results

The results section is organised according to the research questions.

1. **Can primary age students with ASD and ID correctly solve addition and subtraction word problems following schema-based instruction?**

All students improved in the number of correctly solved problems (Figure 1). In Study A the average number of correctly solved problems (max 40) at pre-test was 9 (range 1 to 15) and at post-test was 33 (range 32 to 34). In Study B the average number of correctly solved problems (max 40) at pre-test was 10 (range 4 to 13) and at post-test was 33.7 (range 23 to 40). See Figure 1 for average correct problems pre and post-test for individual participants.

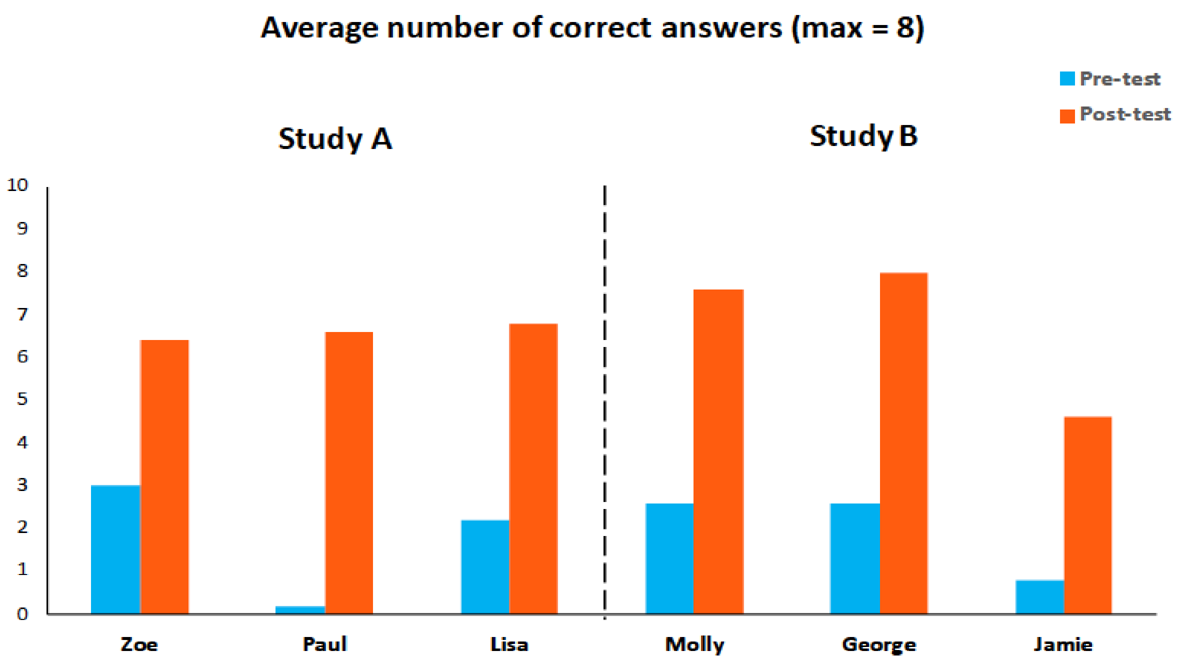


Figure 1. Average number of correct answers pre and post-test, Study a and Study B.

Figure 2 shows the effects of SBI on total problems solved correctly. During baseline the maximum score for any student was 4 (max 8) which was achieved on one probe. Visual analysis of the graphs show a functional relationship between SBI and number of correctly solved problems. Performance of two of the participants showed an increase in correct answers but some inconsistency during the intervention phase. All three participants maintained gains at post-test.

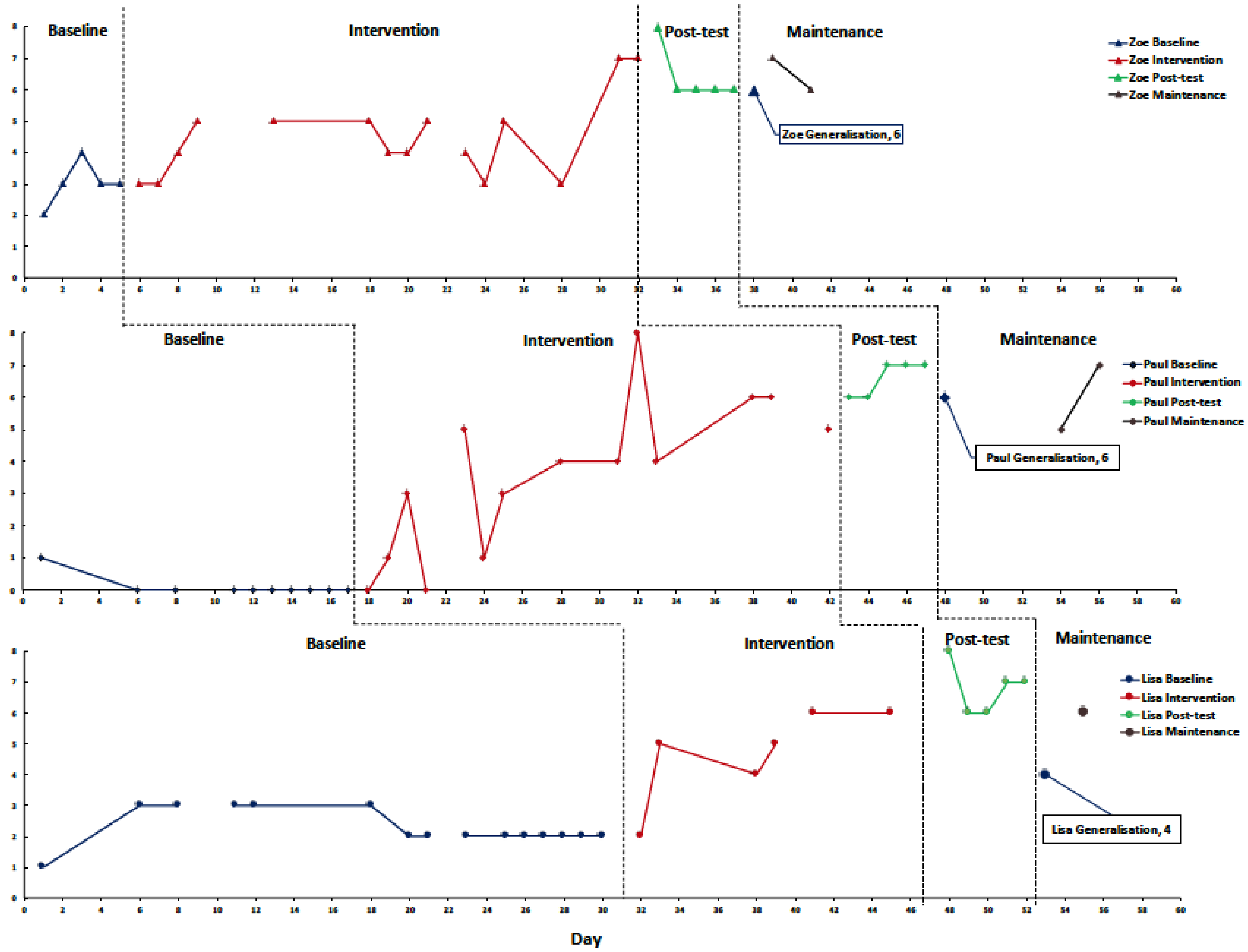


Figure 2. Total number correct problem answers of individual participants in Study A at baseline, intervention, post-test, generalisation and maintenance.

2. Can students independently follow the problem-solving steps?

All students improved in their ability to follow the problem-solving steps (Figure 3). In Study A the average number of steps completed independently at pre-test was 9.9 (range 1 to 14.6) and at post-test was 42.3 (range 39.2 to 45.4). In Study

B the average number of steps completed independently at pre-test was 16.5 (range 12.8 to 18.8) and at post-test was 39.5 (range 34.6 to 44.4).

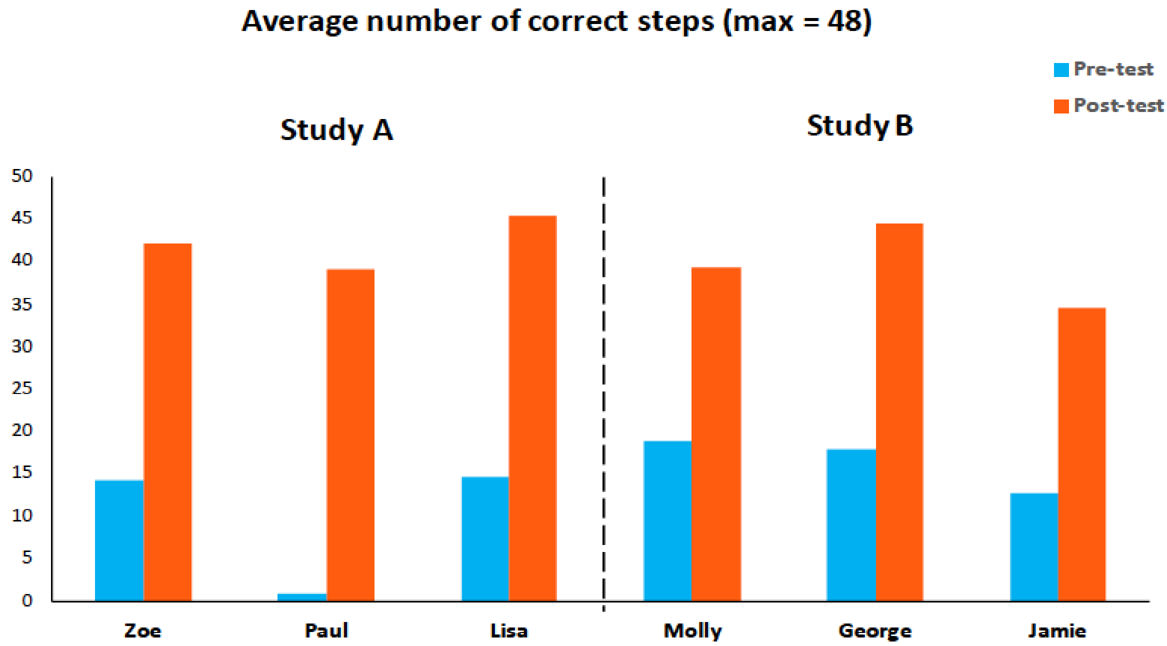


Figure 3. Average number correct problem-solving steps of individual participants in Study A and Study B.

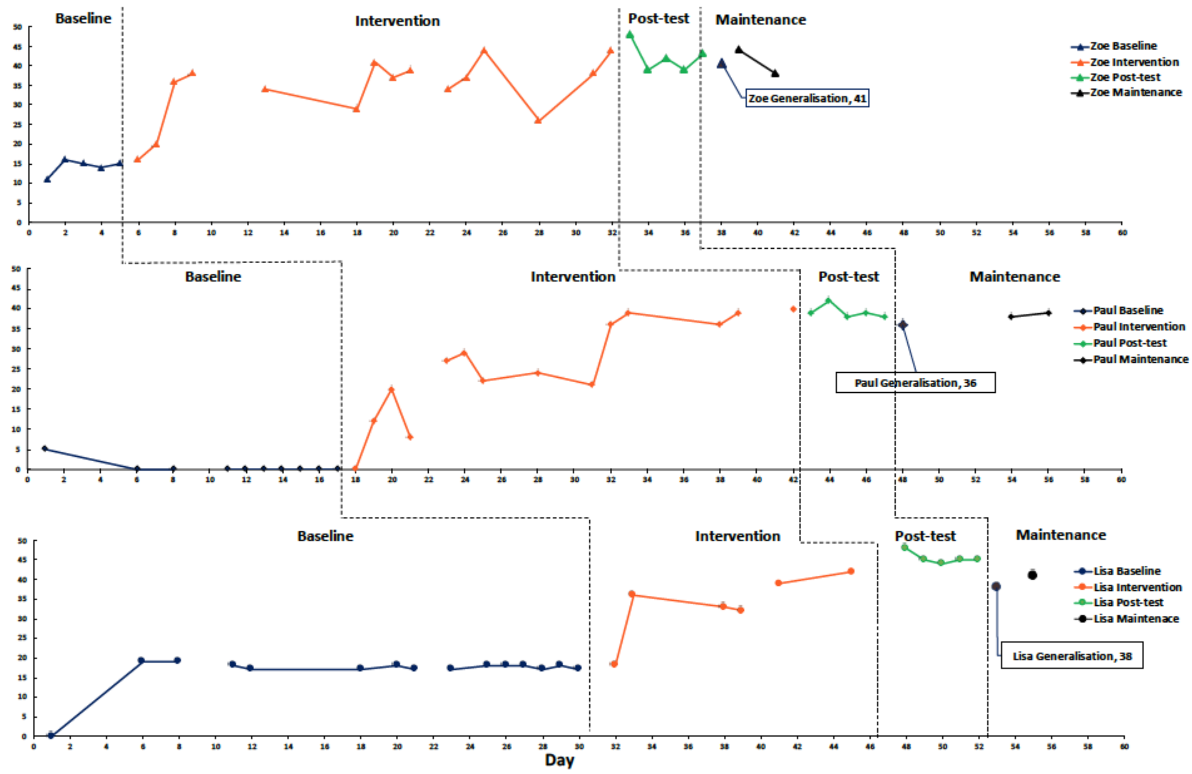


Figure 4. The number of FOCUS steps completed by participants in Study A at baseline, intervention, post-test, generalisation and maintenance.

To ascertain the effectiveness of the intervention, percentage of data points in the treatment phase exceeding the median at baseline was calculated (PEM) (Ma, 2006). All calculations were between 70% and 100%. PEM >90% is said to be highly effective and 70% to less than 90% moderately effective. As can be seen in Table 2 at post-test the SBI intervention was highly effective for all 3 participants.

Table 2

Percentage of data points exceeding the median

	PEM at different phases							
	Intervention		Post-test		Generalisation		Maintenance	
	Problem solving steps	Correct answer	Problem solving steps	Correct answer	Problem solving steps	Correct answer	Problem solving steps	Correct answer
Zoe	1.00	0.73	1.00	1.00	1.00	1.00	1.00	1.00
Paul	0.93	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lisa	0.83	0.83	1.00	1.00	1.00	1.00	1.00	1.00
Mean PEM	0.92	0.85	1.00	1.00	1.00	1.00	1.00	1.00

3. Do students enjoy schema-based instruction and find it useful?

All participants agreed, either a little or a lot, that: I liked the maths lesson with Dr Mills/Dr Howell; I can use FOCUS by myself; and I can use FOCUS in my maths lessons. Five of the six participants agreed, a little or a lot, that: I liked using the iPad in maths; using the iPad helped me solve problems; FOCUS could help other students learn to solve maths problems. When asked whether FOCUS could help other students solve problems, one student marked 'not at all.' Three of the six students said they were not sure using the FOCUS checklist helped them solve problems. Students were also asked to recite what the mnemonic FOCUS stood for (i.e., **F**ind the problem type, **O**rganise information, **C**reate a number sentence, **U**se the numberline, **S**olution). Five of the six students accurately recited the steps.

Stage 2 Methods, Data Collection and Results

Design

A mixed-methods, action research design was used to address the research questions in Stage 2, which focused on using the strategy more broadly across the school. Action research is an approach that involves participants in a change process.

It is undertaken in a specific, practical context to lead to professional development, and involves planning and implementing an action, evaluating the results of the action, reflection, and replanning (Koshy, Koshy & Waterman, 2011). It is a spiral process that can include many iterations, and is fluid as learning occurs throughout the process. This design suited our project as we developed and refined SBI for a wider audience of students and teachers.

Data Collection

Data on both students and teachers was collected to address the research questions.

Student data. Students were given a pre-test prior to the start of instruction, and a post-test immediately following the end of instruction. In Stage 2 instruction focused on *group* problems, which are part-part-whole problems. Each test consisted of six group word problems. Tests were administered individually and followed the same procedures as pre- and post-testing in Year 1. The same data collection sheet was used as well, which included information about whether the problem was solved correctly and if the steps of FOCUS were followed. Classroom teachers collected data on their own students following training (described below).

Teacher data. Data collected on teachers included teacher pre- and post-surveys, fidelity of treatment data and artefacts.

Teacher surveys. Prior to the start of training, teachers completed a pre-training survey that included eight Likert scale items about their confidence teaching problem solving and their students' ability to solve word problems. For instance, teachers were asked to rate their agreement with the following statements: "I enjoy teaching maths problem solving to my students," "My students can understand word problems," and "My students are good at solving maths word problems." In addition to the Likert items, teachers were asked to respond to three short answer questions: Please describe your current approach to teaching word problems in maths; What are your goals for students in regards to maths problem solving? and What would you like to get out of working with the coach over the next six weeks?

The post-survey included the same Likert scale items as the pre-survey, as well as additional items around the effectiveness of the FOCUS strategy (e.g., "FOCUS helped my students improve their word problem solving skills") and the effectiveness of the PD approach (e.g., "How useful were the individual or team coaching sessions?"). There were also four short answer items included on the post-survey (e.g., "What challenges were there in implementing FOCUS with your students?").

Fidelity of treatment. Fidelity of treatment data was collected to evaluate teachers' ability to accurately implement the FOCUS intervention. Teachers were given fidelity of treatment checklists for each lesson that listed the key components of the lesson and provided spaces for the teacher to check the activities off as they occurred, as well as a space to note any modifications or adjustments made. Teachers were instructed to complete the checklist either during or directly after each lesson. Researchers completed the same checklists during their weekly observations of teachers during the six-week coaching cycles. This provided a measure of reliability to teacher self-reports.

Artefacts. A number of artefacts were collected throughout the coaching cycles. These included materials teachers made to support student learning (e.g., enlarged graphic organisers, group word problems), teachers' lesson plans on which they noted any changes they had made to instruction, coach-teacher meeting notes, work done during the one-day training, and so on.

Intervention Design

Lesson materials. Based on our learning from the Stage 1 studies, the research team developed lessons scripts and materials for *group* word problems. We chose *group* word problems, rather than *change* problems, for this intervention as they are an easier problem type to learn. As in Stage 1, the lesson scripts followed a strategy instruction approach that included the following steps: (1) develop background knowledge, (2) consolidate the problem type, (3) introduce the graphic organiser, (4) introduce FOCUS and use it to solve word problems to find missing big group (i.e., final position missing), (5) use FOCUS to solve word problems to find missing small groups (i.e., missing addend problems), and (6) independent practice without the graphic organiser and checklist.

Professional development. A professional development package was designed to train teachers in the SBI approach and support them as they implemented it in their classrooms. This package consisted of a one-day training, followed by six weeks of individual or team instructional coaching and fortnightly cohort meetings. The one-day training took place at MUSEC and began with a review of the *Working Mathematically* outcomes from the NSW Mathematics K-10 Syllabus (NSW Education Standards Authority, 2012, p 38-39). Teachers then evaluated their students' current performance in relation to the outcomes. Next teachers took part in a maths problem solving exercise and developed a visual representation of the maths problem solving process. With this process in mind, they listed difficulties their students might have with maths problem solving (e.g., difficulty reading or comprehending the word problem, lack of fluency with maths facts).

With this background knowledge in place, teachers read and summarised an article on MSBI (Spooner et al., 2017) and saw a presentation on the Stage 1 studies given by the researchers. The afternoon portion of the day was dedicated to sharing the lesson materials with teachers, modelling the lessons for them, and providing feedback as they practiced teaching the lessons to each other. The final activity was practice scoring the pre-assessment. To do this, the group watched a video of a student taking the assessment and were asked to score her using the scoring sheet. After each problem, the video was paused so teachers could discuss how they scored the student. This was done to ensure accurate pre- and post-test data collection. Appendix H contains the facilitator's guide for the one-day training, and Appendix I contains the handouts the participants used throughout the day.

During the six-week coaching cycle, teachers received coaching from either Dr Howell or Dr Mills using a student-centred coaching approach (Sweeny, 2011). Some teachers worked with the coach one-on-one while others worked as classroom teams. A coaching plan (see Appendix J) was customised for each teacher. The plan identified goals for the teacher and students to accomplish over the six weeks, as well as the type of support the coach would provide. Each week, the coach observed a maths lesson and met with the teacher for planning. When observing the lesson, the coach could perform a variety of roles such as collecting student data, co-teaching or modelling a lesson. The weekly meeting followed a set format (see Appendix K) and centred around looking at student data. The data allowed the teacher to analyse what students knew and what they were having difficulty with. From there, the teacher planned how to address these misunderstandings and the type of support the coach would provide.

In addition to the weekly coaching sessions, three fortnightly cohort meetings were scheduled throughout learning cycle. During the first meeting, teachers discussed results of the pre-assessment and shared adaptations and modifications they had made to instructional materials to help meet individual student needs. The second cohort meeting focused on writing word problems according to the steps outlined in Spooner et al. (2017), which teachers could use during lesson. Teachers worked in pairs, receiving support from the instructional coach as they worked. The final cohort meeting included a carousel activity with questions designed to help teachers reflect on student and teacher growth during the learning cycle. They also completed the post-professional development teacher survey.

Participants

Teachers. All classroom teachers at MUSEC (*n*=14) participated in the study. All participants were female with an average age of 41.64 years (range = 25-58 years) and an average of 12 years teaching experience (range 2-32 years). Three teachers were classified as Master Special Educators five were classified as Special Education Instructors and six were classified as Classroom Assistants All of the teachers had completed studies in special education. Twelve teachers had Master degrees in special education, one had a special education diploma, and one had a learning difficulties support teaching certificate. On average, teachers had worked at MUSEC for 8.25 years (range = 2-19 years). Table 3 provides information about the teachers by cohort.

Table 3

Teacher Participants by Cohort

Cohort	Mean age (SD)	Teaching level	Mean years teaching (SD)	Mean years at MUSEC (SD)
Cohort 1 (*n*=7)	41.64 (12.04)	MSE=1 ISE=4 CA=2	12.50 (9.43)	8.79 (5.37)
Cohort 2 (*n*=7)	42.14 (15.70)	MSE=2 ISE=1 CA=4	11.57 (7.63)	7.71 (6.65)

Note. MSE=Master Special Educators, SEI=Special Education Instructors, CA=Classroom assistants

Students. Thirty-one students (21 boys, 10 girls) participated in the study, spanning grades kindergarten through year six. The average age of student participants was 9 years (range = 5-12 years). All students in the school have a disability as a pre-requisite of enrolment. Twenty-three participants had a diagnosed Autism Spectrum Disorder (ASD), 13 had a mild intellectual disability, 7 had a moderate intellectual disability and 3 had a language disability. These numbers include 15 students with a dual diagnosis of both ASD and an intellectual disability

(ID). While most students in the school participated in the study, 12 students did not. It was decided not to include these students because they either did not have the prerequisite skills of one-to-one correspondence or numeral recognition (*n*=9) or they had already received instruction in SBI (*n*=3). Table 4 shows participant characteristics by cohort.

Table 4

Student Participants by Cohort

Cohort	Mean age (SD)	Gender
Cohort 1	8.84	13 boys
(*n*=19)	(0.83)	6 girls
Cohort 2	9.25	8 boys
(*n*=12)	(2.38)	4 girls

As part of enrolment in the school, parents provide consent for data to be collected for research purposes during students' regular instruction. As SBI was implemented as part of regular maths instruction in all classrooms, additional permission was not sought. Parents were informed of the school-wide maths project via the school newsletter. Individual classroom teachers also sent information about the intervention to parents periodically as part of their regular classroom communication.

Procedures

At the beginning of the 2018 school year, teachers were informed about the plans for professional development and classroom teaching teams were allowed to select whether they would participate in the program during Term 2 (cohort 1) or Term 3 (cohort 2). Two classrooms elected to be part of cohort 1, and two classrooms elected to be part of cohort 2. In the teacher preparations days prior to the start of Term 2, cohort 1 teachers attended the full-day training on SBI led by Dr Mills. The teacher pre-professional development survey was administered at the training, prior to the beginning of the session. Then, the coaching cycle ran for the first six weeks of the term. The teacher post-survey was administered at the cohort meeting the last week of the cycle. All students were pre-tested during week 1 of the learning cycle. Because SBI is a criterion-based intervention, students were post-tested as they completed the intervention. For some students, this was at the end of the six weeks, for others it was at the end of Term 2, and for some it was during Term 3.

Based on teacher feedback and the artefacts collected from cohort 1, adjustments and modifications were made to the teaching materials prior to the start of cohort 2. Specifically, portions of the lesson script were clarified. Lessons 4 and 5 were rewritten to provide more detailed instructions, and tweaks in other lessons were made to make the instructions clearer. Data sheets for lessons 4 and 5 were modified to allow for more detailed data collection. Student materials were modified as well, based on changes teachers had made to accommodate individual student needs.

During the teacher preparation days prior to Term 3, cohort 2 completed the teacher pre-professional development survey and participated in the one-day SBI training. Students in their classrooms completed the pre-assessment during week 1. The six-week learning cycle ran from week 3 to week 9 during the term. (The extra week of the cycle was due to the coaches being away one week at a conference.) At the final cohort meeting, teacher completed the post-survey. As with cohort 1, students were post-tested as they completed the intervention. Twenty students completed the intervention by the end of Term 3 and their results are included in this report. Eleven students had not completed the intervention at the time of this report, so their post-test data is not included in this report.

Data analysis

Student data. Student pre-post data was examined in two ways. First, the total number of items correct was calculated, with a total possible score of 6. Next, the total number of focus steps completed independently was calculated, with a total possible score of 36 (6 steps per item). Means and standard deviations were calculated, and matched pairs t-tests were run to determine the significance of results.

Teacher data. Three types of teacher data were analysed – fidelity of treatment, pre-post surveys, and artefacts from the training and coaching sessions. Fidelity of treatment data was analysed by calculating the total number of lesson components completed and dividing it by the total number of lesson components on the fidelity of treatment checklist for that step. Descriptive statistics were used to determine the overall fidelity of treatment, the fidelity of treatment for each cohort, and the fidelity of treatment for each step of instruction.

Teacher pre-post surveys were analysed in two ways. For the Likert-scale items that appeared on both surveys, pre- and post-survey means and difference scores were calculated for each item. For the Likert scale items that only appeared in the post-survey, overall descriptions of results are reported. Teacher responses to short answer questions were coded to look for themes within each teacher's response and across all teachers' responses.

Finally, artefacts from the coaching and training session were reviewed to look for evidence of the modifications and adaptations teachers made to the instructional materials to meet student needs. Additionally, artefacts were reviewed to look for evidence of changes in teacher attitudes toward and efficacy for teaching maths problem solving.

Stage 2 Results

The results section is organised according to the research questions.

Question 1: What adjustments and modifications to teaching materials are required to meet the needs of all students at MUSEC?

A number of adjustments were made by teachers to meet individual student needs. To make materials more accessible to students with fine motor difficulties or limited verbal responses, teachers in two classrooms used Velcro pictures for the 'whats' and the 'labels' and Velcro numerals that students could select rather than writing the numbers and words on the graphic organiser. Two teachers allowed younger students to dictate their answers for the same reason. One teacher enlarged the graphic organiser to make it easier for her student with fine motor difficulties to manipulate blocks when counting. Likewise, adjustments were made to the graphic organiser and FOCUS checklist between cohorts 1 and 2 to make them more self-explanatory for students.

To increase student engagement and comprehension, teachers across all classrooms reported writing group word problems that matched students' particular interests or common experiences in the classroom. For some students, teachers made the word problems more challenging by removing the picture prompts or using larger numbers. Other teachers added in additional 'mini-lessons' to correct student misunderstandings. For instance, one teacher included practice with 'same' and 'different' at the start of lessons. Another teacher did a mini-lesson focused on step F of FOCUS: Find the problem type. In this lesson, she led students through finding the problem type only, using a number of word problems, to focus on identifying the ‘whats’ and the ‘label.’ In later lessons students then went on to solve the problems using the rest of the checklist.

Question 2: Can student accurately solve group word problems? Can they independently follow the FOCUS steps to solve group word problems?

Pre- and post-test scores were analysed for the 20 students completing the maths intervention by the end of Term 3. Students improved in both their ability to correctly answer group word problems and in their ability to independently follow the FOCUS problem-solving steps. At pre-test, students scored an average of 2.4 out of a possible 6 items problems correct (SD=1.73) and at post-test scored an average of 5.0 problems correct (SD=1.52). A paired samples t-test found this to be a significant result (t=5.94, p=0.000). Similarly, at pre-test students completed an average of 8.35 (out of 36 possible) problem solving steps (SD=5.49), and at post-test they completed an average of 28.85 steps (SD=5.55). Again, this was a significant result (t=18.37, p=0.000). The 11 students who did not complete instruction by the time of this report had similar pre-test scores (M correct=1.27, SD=1.74; M steps completed = 7.64, SD=5.46) to those that finished, indicating that they may make similar gains.

Question 3: Can teachers implement SBI with a high degree of fidelity?

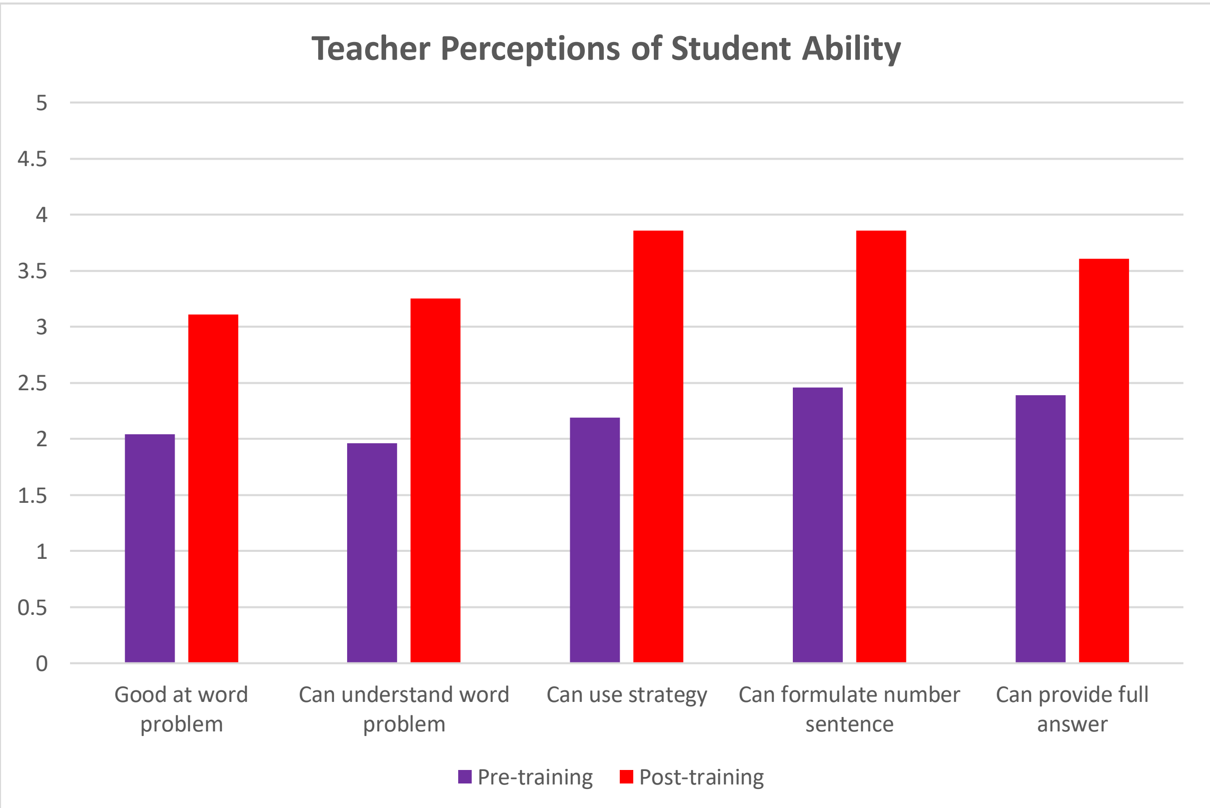
The overall fidelity of implementation, across all teachers and across all steps, was 87%. Both cohort 1 and cohort 2 had similar levels of fidelity – 88% and 86%, respectively. A closer look at fidelity by instructional step revealed that teachers had high rates of fidelity for step 1 (96% fidelity), step 2 (94% fidelity) and step 5 (94% fidelity). Fidelity was lower for steps 3 (88% fidelity) and 4 (75% fidelity). In step 3, three teachers omitted some steps of the teacher model. Other omissions included not stating the objective at the beginning of the lesson and not reviewing the rule for group problems at the end of the lesson.

Step 4 was the step students stayed in for the most instructional time, as this was the step during which they began practicing solving word problems with the graphic organiser and checklist. By far, the most commonly omitted component of instruction during step 4 was reviewing the FOCUS mnemonic at the end of the lesson. Four teachers also failed to use levelled prompting during guided practice. This corroborates notes on coaching plans and from cohort meetings that indicate teachers found using the levelled prompting guide difficult to manage and that it needed to be modified to be more user friendly.

Question 4: Do teachers find the strategy effective for student learning? Which components of FOCUS are most useful?

Twelve teachers (86%) agreed or strongly agreed that FOCUS helped their students improve their word problem solving skills and that other students would benefit from learning the strategy. Figure 5 shows both pre- and post-teacher survey results regarding their perceptions of students' ability to solve word problems. Teachers saw improvements in their students' ability to understand what a word problem was asking, use a strategy to solve the problem, formulate a number sentence and provide an answer.

Of the instructional resources provided, teachers reported that the sample word problems were the most useful, followed by the data collection sheets. Most teachers also agreed that the lesson scripts and data collection sheets were useful. When asked which student materials most contributed to student learning, teachers overwhelmingly agreed that the graphic organiser and FOCUS checklist were the most useful. They also felt the lesson scripts contributed to student learning, but did not feel that the data collection sheets contributed to student learning.



Question 5: Which professional development approaches were most highly valued by teachers?

Overall, teachers reported positive outcomes as a result of their participation in the professional development activities. They reported increases in their confidence teaching maths problem solving, the amount of time they spent teaching problem solving, and their enjoyment of teaching problem solving. Figure 6 compares pre- and post-teacher survey results on these questions.

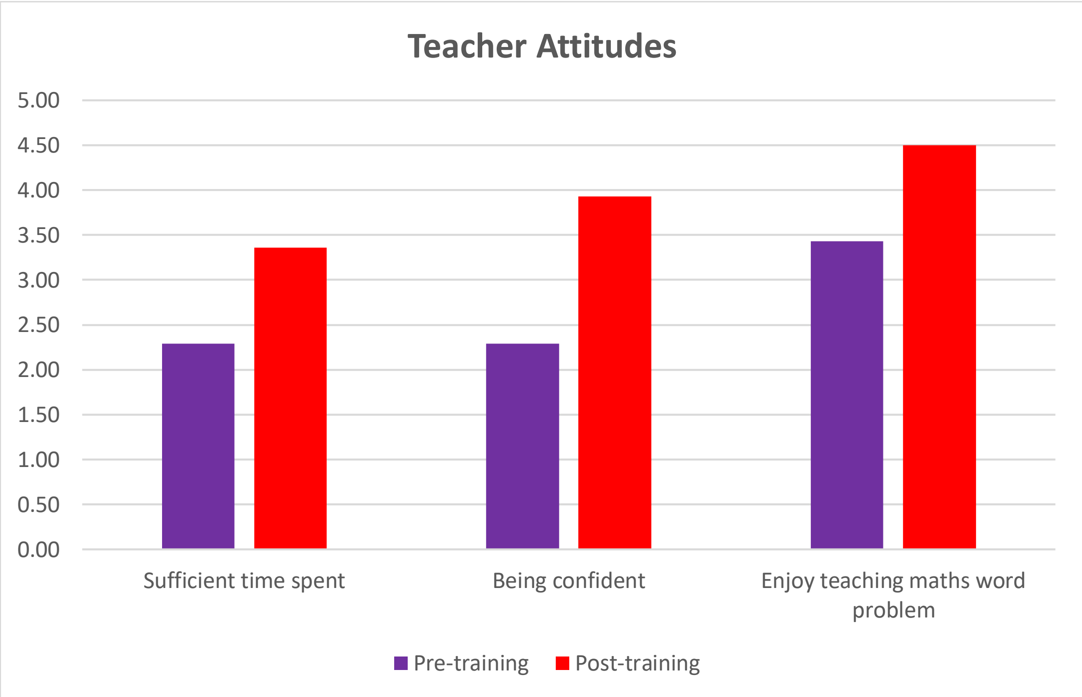


Figure 6. Teacher attitudes before and after professional learning.

All teachers felt that the three professional development components – the one-day training, coaching sessions and fortnightly group meetings – were useful or very useful. When asked which components of the one-day training were most essential to improving their instructional practice, teachers reported that guided practice implementing the FOCUS lessons and writing word problems were very essential. They also felt that reading and discussing an article on MSBI (Spooner, et al., 2017) and hearing about Stage 1 of the FOCUS study at MUSEC were somewhat essential to improving their practice. Teachers did not feel that reviewing the NSW Syllabus *Working Mathematically* outcomes was helpful.

Teachers found all components of the individual and team coaching sessions to be very essential to improving their instructional practice. Having the coach observe lessons, planning and debriefing meetings and analysing student work were rated the most highly, along with data collected by the coach. During fortnightly group meetings, teachers found discussing instructional issues with other teachers and creating materials equally essential to improving their practice. When asked about their preferred methods of receiving professional development, most teachers preferred either small group or coaching sessions, with only 2 of the 14 teachers preferring large group training sessions. All teachers agreed or strongly agreed that MUSEC has the potential to extend and expand the use of FOCUS to improve student outcomes.

Discussion

Prior to intervention many students in the Stage 1 studies attempted to solve all problems by simply adding the two numbers that appeared in the question. At pre-test or baseline some students did not attempt to solve any of the problems. Post intervention all participants in Stage 1 of this project were able to distinguish between addition and subtraction problems and made gains in both the number of problems solved correctly and the number of problem-solving steps completed independently. Once they were familiar with the problem-solving process, students in Stage 1 did not rely on the FOCUS checklist.

Stage 1 of this project implemented SBI as it applies to *change* problems. In developing the MUSEC FOCUS intervention the researchers made a conscious decision to include problem examples with the missing amount in different positions (e.g. $3 + 6 = x$, $3 + x = 9$, $x + 6 = 9$, $9 - 6 = x$, $9 - x = 3$, $x - 6 = 3$). Missing minuend and subtrahend problems proved to be particularly challenging for some students. While these students could fill in the schema correctly they were often unable to use the number line to solve for a missing minuend or subtrahend and to a lesser degree missing addend. SBI and MSBI studies reported in the special education literature typically only include examples in which the missing amount is in the final position. Future research could examine the extent to which knowledge of basic addition facts impacts on students' ability to solve missing addend, missing minuend and/or missing subtrahend problems. Dr Saunders, our academic mentor, suggested that instruction begin with students making concrete representations of the problem regardless of whether or not a student has basic fact knowledge. Future research may determine whether starting with concrete models assists students. In Stage 2 of the project all students learnt to use concrete materials to map the problem onto the schema.

Part of students' success was driven by teachers' ability to make modifications and adjustments to the instructional materials to meet individual student needs. While some of these modifications addressed accessibility (e.g., enlarging materials, Velcro materials) others addressed student understanding (e.g., using larger numbers, creating mini-lessons). Teachers proved adept at identifying student challenges and making modifications to meet these needs. Teachers in both stages had some difficulty in sticking absolutely to the scripts. Teachers tended to modify instruction to suit students' performance. This was evident in in Step 5 of Study A and Study B where both researchers tended to provide guided rather than modelled practice in using the checklist. Post test scores of the number of independently performed problem solving steps suggest that guided practice was sufficient for students to master the steps.

As Peltier and Vannest (2017) reported in their meta-analysis of schema-instruction, teachers' rates of fidelity of treatment were lower than researcher rates. In both stages of the MUSEC project, this was occasionally due to an omission in key instructional components (e.g., use of levelled prompting). However, in most cases this was due to smaller omissions, such as not stating the objective at the beginning of the lesson, or not reviewing what the FOCUS mnemonic stands for at the end of the lesson. While all omissions impacted fidelity of treatment numbers equally, all omissions were not qualitatively equal.

From a teacher perspective, adhering to levels of prompting proved to be a challenge for teachers in both Stage 1 and Stage 2 of the project. Whether this would become easier with greater familiarity with the scripts and program materials is not known. The impact on student learning is also unknown. This research raised prompting as an area that warrants teacher reflection. With many MUSEC students having external 1:1 Applied Behaviour Analysis (ABA) therapy with high levels of prompting, prompt dependence can be an issue. As teachers it is important to provide the least intrusive prompts possible and to allow sufficient 'wait' time before providing a prompt or modelling the desired response. Ongoing implementation of SBI at MUSEC will need to address levels of prompting.

Teachers' experience with the professional development components of this study mirrored the findings from research. Teachers found the learner-centred tasks of practicing lesson delivery prior to teaching students, writing word problems, and getting support during their maths instruction to be the most essential ingredients to improving their practice. This aligns with Dunst, Trivette and Hamby's (2010) finding that learner-centred tasks resulted in larger gains in teacher knowledge, skills, self-efficacy and attitudes than instructor-centred tasks. The professional development provided in this study followed the suggestions from Yoon et al. (2007), with an initial training and on-going support delivered over more than 14 hours. Similar to the findings in that meta-analysis, this intensive teacher training led to measurable gains in student achievement.

Limitations

There are a number of limitations to this study. First, this study was conducted in a small school within a university context. All teachers who participated in the study had advanced degrees in special education, most with Master's degrees. This context is quite different from a typical school setting, which may not have the same level of teacher training or the same evidence-based practice focus. Similarly, the students who participated in this study primarily had ASD and/or ID. Students with ASD and ID constitute a small percentage of the total school population. SBI might result in different outcomes for students with other learning profiles.

Another limitation of this study is that the people who conducted the research – Drs Howell and Mills – were the same people who provided the professional development to teachers. Not only does this raise questions about potential bias in interpreting results, but it also raises concerns about whether teachers felt comfortable providing an honest critique about the program. While pre-post teacher surveys were not linked to individual teachers, teachers still knew that their principal or a master teacher would be reading them.

The rates of fidelity of treatment are a concern in that they are lower than fidelity of researcher-implemented interventions (Peltier & Vannest, 2017). While most of the omitted lesson components were non-critical components (e.g., stating the objective, reviewing the rule for group problems at the end of the lesson), some critical components (e.g., parts of a teacher model, use of the levelled prompting guide) were omitted as well. Perhaps adjusting the structure of the professional development to model and provide guided practice for teachers on lesson implementation throughout the process, rather than front loading it during the one-day training, could help improve instructional fidelity. Some teachers reported difficulty with managing all the lesson materials and felt that it was too difficult to record prompt levels whilst teaching.

Implications

If schools are serious about improving student achievement, investments must be made to provided on-going, job-embedded professional development. The current approach of sending teachers to workshops and training sessions and expecting that to improve teacher practice and student achievement is ineffective (Yoon et al., 2007). While the workshop approach may be the path of least resistance to ensuring teachers meet their professional development hours for accreditation and for schools to say they are focused on improvement, evidence would suggest that in reality it is not a wise use of precious education dollars. Schools must do the hard work of investing in the kind of professional development that makes a difference for students. Instructional coaching is one of the most effective methods for improving teacher practice and student learning (Dunst, Trivette & Hamby, 2010). Consistent with implementation science, this project demonstrates the value of professional learning that recognises teachers' knowledge of their students as a critical component for effective implementation of evidence-based strategies. Without this knowledge, evidence-based practices may not meet the needs of all students. They may only be suitable for students who fit the exact profiles of students in the research studies. Most real-world classrooms, however, have a larger variety of students, making teacher skills at modifying and adjusting instruction critical for success.

Recommendations for future research

While the results of this study are certainly promising, additional research is required to fully understand the effectiveness of SBI and this approach for teacher professional development. One critical question is whether the positive changes in teacher practice and student achievement will be maintained over time once the intensive professional development has ended. This is a much-needed area of research. Another area for future research is developing approaches to increase the fidelity of treatment of classroom teachers when implementing evidence-based practices in their classrooms. Additionally, future research should explore whether the professional development approach outlined here is effective in other school settings and with teachers who do not have the same level of training (i.e., Master's degrees, special education certification) as the teachers in this study. Finally, more research is needed to determine if the version of SBI developed for this school-based research project is effective in improving the mathematical problem-solving skills of other student populations, such as students with learning difficulties.

Conclusion

This two stage research project points to implications for teaching problem solving skills to students with ASD and ID, and for providing effective professional development to improve student learning outcomes. First, student outcomes from both Stage 1 and Stage 2 of this project clearly indicate that, when teachers implement a strategy instruction approach, students with ASD and ID can improve their comprehension and learn to apply basic maths skills to solve addition and subtraction word problems. This type of instruction should be incorporated as part of a comprehensive educational program for these students. Second, results from Stage 2 of the project demonstrate that, given the right level of support, teachers are able to implement evidence-based practices in their classrooms with fidelity, and to make the adjustments and modifications necessary for their students to improve their skills in maths problem solving. The results of this school-based research project add support both for SBI as an evidence-based practice and for instructional coaching as an effective method of improving teacher practice.

Research to Practice Impact

Participation in this AIS School Based Research Project afforded MUSEC teachers the opportunity to engage in a research-to-practice journey that was grounded in evidence-based practice both in terms of the teaching strategy they learned and the model of professional learning with which they engaged. The involvement of an academic mentor who was able to demonstrate the translation of her research to classroom practice in each of the MUSEC classrooms was a powerful motivator for all teachers (see Dr Alicia Saunders biography in Appendix L). The two ‘small n’ studies conducted in Stage 1 of the project provided valuable evidence that SBI and the professional learning that teachers were to undertake in Stage 2 were relevant in the MUSEC context.

Many teachers at MUSEC have been working in the school for a long time. For some of these teachers this SBRP served to ignite their enthusiasm for learning and implementing something new. Teachers responded that participating in research was:

- *"Cool because it was relevant, it works, it was empowering and interesting;"*
- *"Interesting and fun;"*
- *"Worthwhile because it allowed us to teach the students something we would not otherwise have done;" and*
- *"An opportunity as we were given regular feedback regarding our teaching as well as being mentored in areas where I thought I needed guidance*."

When asked about their students' reaction teachers noted student were:

- *"Excited,"*
- *"Motivated,"*
- *"Proud and happy when they say the rule,"*
- *"Proud and happy when they use the FOCUS checklist," and*
- *"Excited to see their ownership of learning."*

SBI will continue to be a teaching strategy employed across the school. Having had the opportunity to learn about this strategy as part of a research project teachers have expressed enthusiasm to extend the strategy beyond simple problems. Having observed the effectiveness of the coaching model this, too, will continue and it is hoped that different teachers will step up to provide coaching in areas where they have particular expertise. As part of Macquarie University, MUSEC has an ongoing commitment to evidence-based practice, and with all teachers having post graduate qualifications in special education, there has always been an awareness of the important role research has to play in determining effective teaching strategies. Involvement in this SBRP has shone a light on this important facet of MUSEC's work.

The work undertaken within the MUSEC SBRP will inform development of professional learning modules with a focus on SBI and teacher coaching to be offered through the Macquarie University Academy of Continuing Professional Development in Education. Dr Howell and Dr Mills have presented Stage 1 of the research at a number of Australian conferences and to the parent body. It is anticipated that both stages of the project will be presented at future conferences. With the significant impact this project has had at MUSEC it is hoped research-to-practice articles will be accepted in teaching and special education journals. Dr Howell and Dr Mills will be presenting the project to Macquarie University colleagues within the Department of Educational Studies and will present an overview of the entire project to parents. SBI will be embedded in MUSEC practice and as such Macquarie University post graduate special education students, all of whom are required to complete a professional placement at MUSEC, will have the opportunity to see SBI in practice. Dr Howell and Dr Mills have been accepted to present at a special education conference to be held at Cambridge University, UK, in December 2018.

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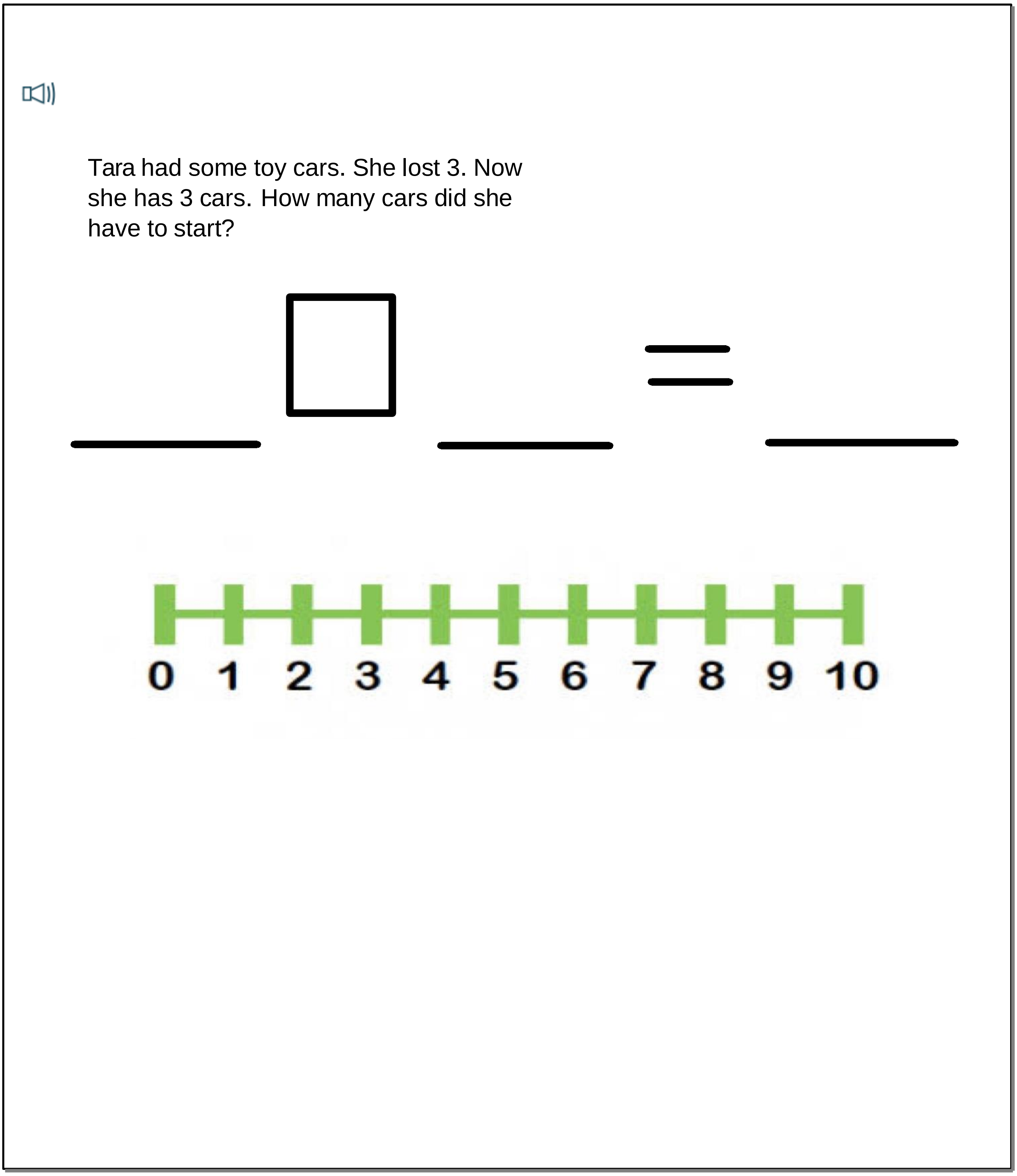
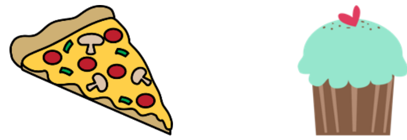
Appendices

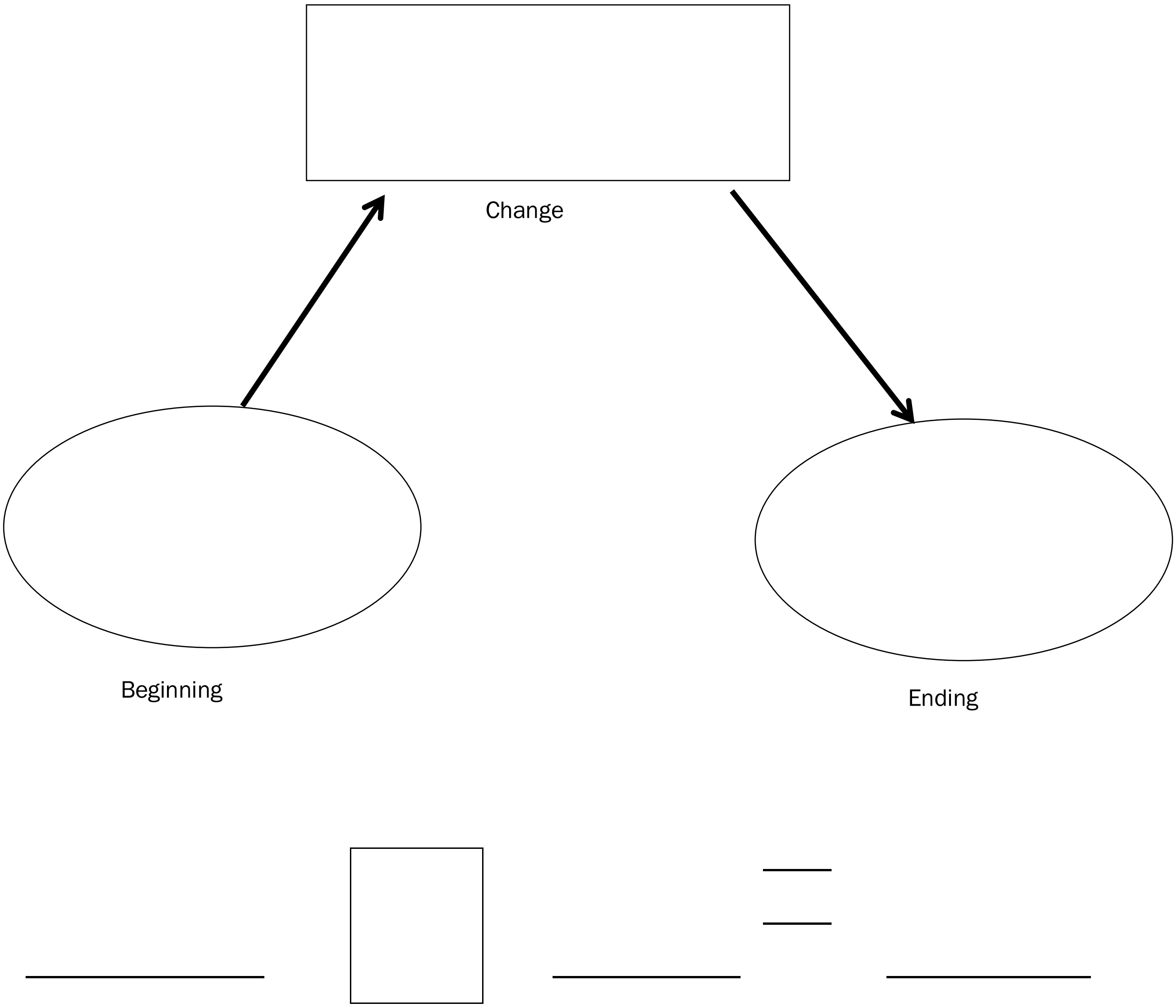
Appendix A: Baseline Testing Sample



Screenshot of what appeared on the iPad. Participants could click on the speaker icon to have the problem read aloud.

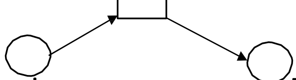
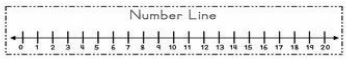
Appendix B: Sample Graphic Organiser





Appendix C: FOCUS Checklist

*Tick one box when you finish one

Find problem type		
Organise information		
Create number sentence	_ ☐ _ =	
Use number line		
Solution		

Appendix D: Levelled Prompt Guide Stage 1

	Level 1 (remind	Level 2 (step + hint)	Level 3 (model and student repeats)
Find problem type	What type of problem is it?	Does the problem have a beginning amount, a change and an ending amount that tell about the **same** thing? What type of problem is it?	The problem has a beginning amount, a change and an ending amount that all tell about **x**. Each part tells about the **same** thing. This is a **change** problem.
Organize information	Which sign?	The change words are - .The change words mean get more/have less.	The change means I add (take away) so I will write the plus sign (minus sign)
Create number sentence	Make your number sentence	Write the numbers you know from the organiser. Leave the part you don't know blank.	Now I will write the numbers from the organiser on the lines in the right place

Appendix E: Prompt Level Data Collection Sheet

Focus data collection

Student: ____________

0= No prompt at all
1= Verbal prompt: "This step says…"
2= Verbal prompt & hint: "This step says…." (+hint)
3= Model with think aloud & student completes the action. Repeat model with think aloud until student completes the action.

	Problem 1					Problem 2					Problem 3					Problem 4				
Date:																				
	F	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3
	O	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3
Probe:	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3
	U	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3
	S	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3

	Problem 1					Problem 2					Problem 3					Problem 4				
Date:																				
	F	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3
	O	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3
Probe:	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3
	U	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3
	S	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3

	Problem 1					Problem 2					Problem 3					Problem 4				
Date:																				
	F	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3
	O	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3
Probe:	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3
	U	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3
	S	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3

	Problem 1					Problem 2					Problem 3					Problem 4				
Date:																				
	F	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3
	O	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3
Probe:	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3
	U	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3
	S	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3

	Problem 1					Problem 2					Problem 3					Problem 4				
Date:																				
	F	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3	**F**	0	1	2	3
	O	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3	**O**	0	1	2	3
Probe:	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3	**C**	0	1	2	3
	U	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3	**U**	0	1	2	3
	S	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3	**S**	0	1	2	3

Appendix F: Stage 1 Script - Step One

Objectives

Students will:

Identify the beginning amount, the change and the ending amount in a change word problem

Describe the features of change problems (a beginning amount, a change, and ending amount, that all tell about the same thing)

Label problems (with a beginning amount, a change and an ending amount that all tell about the same thing), as change problems

Put information from change word problems into a graphic organiser a graphic organiser

Provide solutions to word problems that include a label

Materials: pictures of + and – change word problems, graphic organiser

Note: It may take several sessions to get through each 'step'. At the beginning of each session, show one or two change problem pictures and review the beginning amount, the change and the ending amount. Do this prior to introducing new content.

NB After6 sessions if student still needs prompts to say the 3 parts and 'same' use a whiteboard while reviewing the 2 rules:

Beginning

Change

Ending

Same thing

Step 1: Build background knowledge

Teacher: You are going to learn how to find answers to some word problems. The type of word problem you are learning about is called a change problem.

Lesson Objective: Today you will learn two rules for a change problem.

A word problem is a maths story. Here's a word problem (show picture 1): Tim had 5 stickers yesterday. He got 3 more stickers today. Now he has 8 stickers.

Now you tell me the word problem. (Point to pictures to assist student/s)

Student/s: Tim got 5 stickers yesterday (teacher pointing to group of 5 stickers). He got 3 more today (teacher pointing to group of 3 stickers). Now he has 8 stickers (teacher circling both groups with finger). Rephrase as necessary e.g. If student says "5 stickers" say: "Tim had 5 stickers." Provide verbal prompts as necessary e.g. Tim had.....

Teacher: This word problem tells a beginning amount (point to group of 5 stickers and say: Tim had 5 stickers), then a change, (point to group of 3 stickers and say: He got 3 more stickers) and an ending amount (circle both groups of stickers with your finger and say: Now he has 8 stickers). The beginning, the change and the ending all tell about the same thing.

This type of word problem is called a change problem. In this change problem, there is a beginning amount, a change and an ending amount that all tell about the same thing, Tim's stickers.

Reread the problem: Tim got 5 stickers yesterday. He got 3 more stickers today. Now he has 8 stickers.

Tell me the beginning amount. (Run finger under 5 stickers)

Student/s: 5 (stickers)

Teacher: Tell me the change. (Run finger under 3 stickers)

Student/s: (He) got 3 more stickers

Teacher: Tell me the ending amount. (Run finger under all 8 stickers)

Student/s: 8 stickers

Teacher: Does each part tell about the same thing?

Student/s: Yes

Teacher: This is a change problem. How do we know?

Student/s: It has a beginning amount a change and an ending amount that all tell about the same thing.

If student/s does not respond provide prompts as necessary.

Prompts:

Verbal: What are the parts of the problem? (Student/s: a beginning amount, a change, an ending amount) What 'thing' does each part of the problem tell about? (Student/s: label). Does each part tell about the same thing? (Student/s: Yes) What type of problem is it?

Specific verbal: The problem has a beginning amount, a change and an ending amount. Each part of the problem tells about x. Each part tells about the same thing. If the beginning amount, the change and the ending amount tell about the same thing what type of problem is it?

Model: The problem has a beginning amount (point to first group), a change (point to second group) and an ending amount (circle the two groups) that all tell about x. Each part tells about the same thing. If the beginning amount, the change and the ending amount tell about the same thing it is a change problem.

Teacher: Here's another change word problem (show picture of 6 strawberries in a line with 2 crossed out). The girl had 6 strawberries. She ate 2 strawberries. Now she has 4 strawberries.

Now you tell me the change word problem. (Point to pictures to assist student/s)

Student/s: The girl had 6 strawberries (teacher runs finger under all 6 strawberries). She ate 2 strawberries (teacher runs finger under 2 crossed out strawberries). Now she has 4 strawberries (teacher runs finger under 4 strawberries that are not crossed out).

Teacher: This is a change problem. A change word problem tells a beginning amount (point to whole group of 6 strawberries and say: 6 strawberries), then a change, (run finger under 2 crossed out strawberries and say: she ate 2 strawberries) and an ending amount (run finger under the 4 strawberries that are not crossed out and say: Now she has 4 strawberries). The beginning, the change and the ending all tell about the same thing.

Here's a rule: In a change word problem, all the parts tell about the same thing.

In this change word problem, the beginning amount, the change and the ending amount all tell about the girl's strawberries.

Reread the problem: The girl had 6 strawberries. She ate 2 strawberries. Now she has 4 strawberries.

Tell me the beginning amount. (Run finger under all 6 strawberries)

Student/s: 6 strawberries

Teacher: Tell me the change. (Run finger under 2 crossed strawberries)

Student/s: (She) ate 2 strawberries

Teacher: Tell me the ending amount. (Run finger under remaining 4 strawberries)

Student/s: 4 strawberries

Teacher: The beginning amount, the change and the ending amount all tell about strawberries. All the parts tell about the same thing so this is a?

Student/s: change problem (If student does not finish the sentence model whole sentence and ask the student to repeat.)

Teacher: Can anyone tell me a word problem for this picture? Show an addition story picture. If necessary, prompt the student to say the beginning amount, the change amount and the end amount.

Tell me the beginning amount.

Student/s: answer

Teacher: Tell me the change.

Student/s: answer

Teacher: Tell me the ending amount.

Student/s: answer

Teacher: Do all the parts tell about the same thing?

Student/s: Yes

Teacher: The beginning amount, the change and the ending amount all tell about x. All the parts tell about the same thing. This is a change problem.

Repeat the above process with a subtraction story picture.

Teacher: You have learnt 2 rules for a change problem.

Rule 1: A change problem has a beginning amount, a change and an ending amount.

Rule 2: All the parts tell about the same thing.

Teacher: Tell me the two rules about a change problem.

Student/s: A change problem has a beginning amount, a change and an ending amount. All the parts tell about the same thing.

Appendix G: Stage 1 Lesson Steps

Step 1

DEVELOP BACKGROUND KNOWLEDGE

Using pictures, we discussed word problems as math stories.

We introduced the two rules for a change problem.

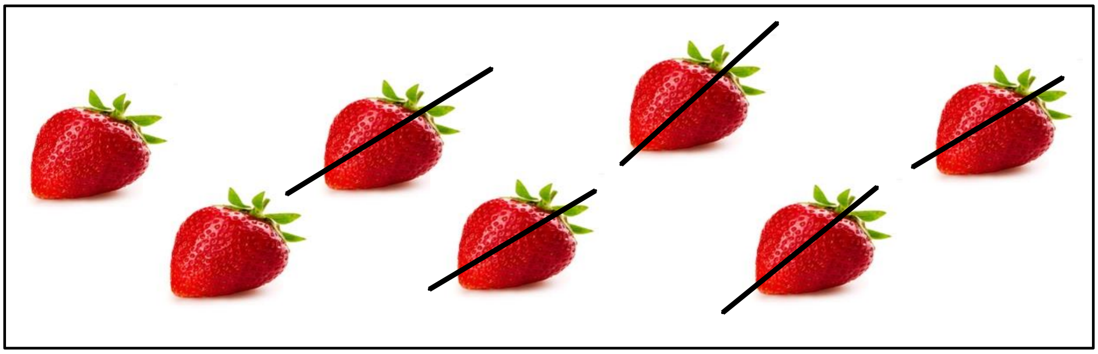
Criterion for step 1: The student can state the two rules for a change problem: (1) It has a beginning, a change and an ending, and (2) all the parts tell about the same thing.

Step 2

INTRODUCE THE CHANGE PROBLEM TYPE

Using pictures prompts students practised telling addition and subtraction word problems.

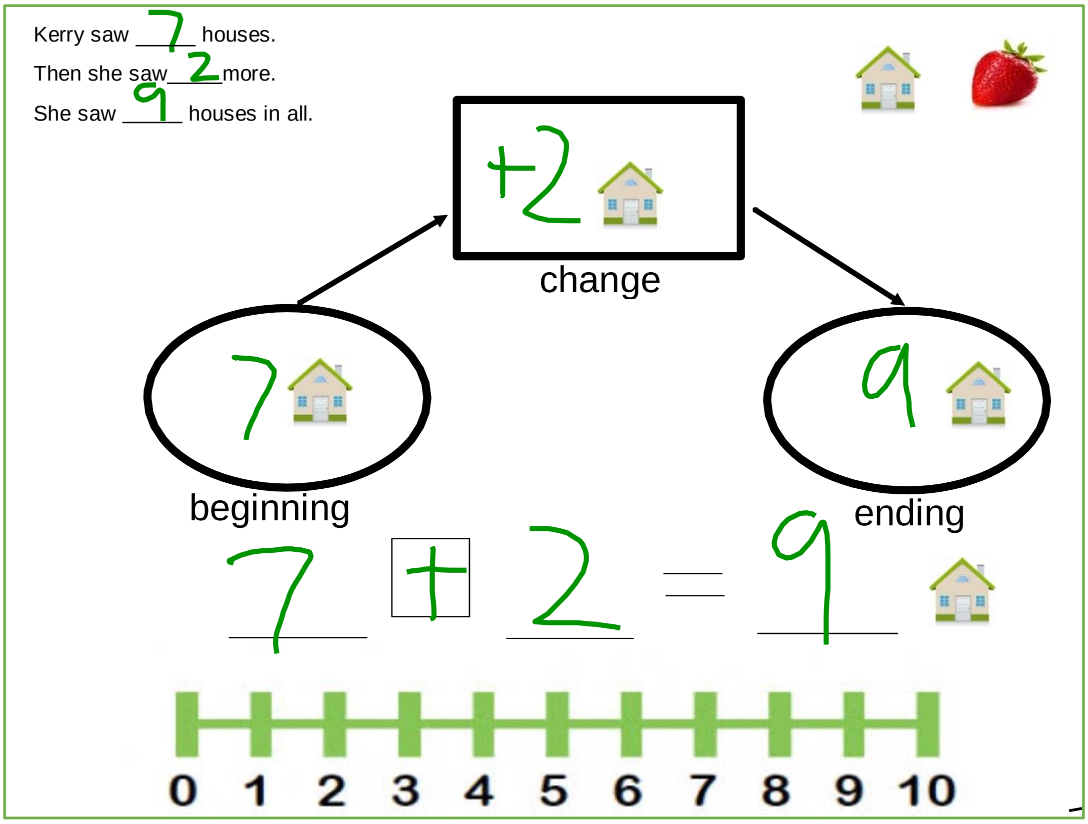
They identified the beginning, change and ending in each problem, and the 'thing' all the parts talked about (i.e., the label).



Criterion for step 2: Given picture prompts, the student tells at least 1 addition and 1 subtraction change problems with no verbal prompting. The student is able to state it is a change problem and why (key vocabulary: beginning, change, ending, same thing).

Step 3

INTRODUCE THE SCHEMA



The teacher introduces the schema (graphic organiser) and **models putting the parts of the change problem into the organiser**, including the label.

The teacher then **models writing the corresponding number sentence**.

Students practise putting change problems into the organiser and writing the corresponding number sentence.

Change problems are written and read aloud by the teacher.

Criteria for step 3: The student correctly places 3 addition and 3 subtraction word problems into the schema and writes the corresponding number sentences.

Step 4

INTRODUCE AND MODEL USING THE FOCUS SELF-MONITORING CHECKLIST

- The teacher introduces the FOCUS mnemonic.
- The teacher models using the FOCUS checklist to solve a change problem when only two parts are known.
- Students start to memorise the FOCUS mnemonic.

Step 5

GUIDED PRACTICE

- Students practise solving a variety of addition and subtraction change problems using FOCUS.
- The teacher provides levelled prompting when errors are made. Levels of prompting are recorded

Step 6

INDEPENDENT PRACTICE

- Students discussed when they might use the organiser in other maths lessons
- The teacher modelled organising the information without using the schema.
- Students practiced solving change problems without using the schema.
- The teacher provided levelled prompting when errors were made. The levels of prompting were recorded.
- In Study B students received additional instruction to solve problems with ‘tricky wording.’

Appendix H: Stage 2 Facilitators Guide

FOCUS Maths Training

Facilitator's Guide

Objectives

Participants will:

- Explain the three working mathematically outcomes in the NSW Mathematics Syllabus;
- Explain the four pillars of the SBI model;
- Identify the features of the three types of addition and subtraction word problems;
- Write a series of group word problems;
- Collect fidelity of treatment data when observing a schema-based instruction lesson;
- Demonstrate a schema-based lesson to peers; and
- Score a pre-assessment using the FOCUS data collection tool.

Materials

Power Point slides, handout packet, teacher pre-training surveys, working mathematically outcomes, highlighters, pens, post-it notes, palm cards, chart paper, textas

Procedures

Time	Instructions	Materials
Introduction (15 minutes)		
9:00-9:05 (5 min)	Welcome, agenda and outcomes for the day	PPT slide 2
9:05-9:15 (10 min)	Administer teacher pre-training survey. Collect it from all teachers when they finish.	pens, surveys
Working Mathematically Outcomes (30 minutes) *Objective: Participants will explain the three working mathematically outcomes in the NSW Mathematics Syllabus.*		
9:15-9:30 (15 min)	Analyse syllabus documents • Refer participants to handout pages 3 • **These sections of the NSW Mathematics Syllabus outline the working mathematically outcomes and content. Take a few minutes to read through it on your own and highlight key words that show what students do when working mathematically.** (5 min) • **Discuss with your table: What does working mathematically mean? What does it look like?** (5 min) • Table groups share out a few ideas to the group. (3 min)	PPT slide 3, highlighters PPT slide 4

9:30-9:40 (10 min)	Connecting to the classroom • Now let's look more closely at the outcomes – communicating, problem solving, reasoning. • On handout page 5, think about the students you will be working with for the maths problem solving intervention. For each student, highlight where they are on each outcome. Start by looking at their stage based on grade level, and work backwards. Show and explain example. • Handout multiple copies of the outcomes and allow teachers a few minutes to rate their students • Share with the people at your table what you are noticing about your students' current working mathematically skills. • Collect student ratings	PPT slide 5, wm outcomes handout highlighters, pens
9:40-9:45 (5 min)	Wrap up • Ask participants to name the three working mathematically outcomes – communicating, problem solving and reasoning – and what each means.	
Introduction to Modified Schema-based Instruction *Objectives: Participants will (1) explain the four pillars of the SBI model, and (2) identify the features of the three types of addition and subtraction word problems*		
9:45-10:05 (20 min)	Problem solving example • Turn to page 6 in your handouts. I'd like you to solve this problem on your own. Then we'll talk about how you solved it. (2-3 minutes) • Take a minute to jot down what you did to solve that problem. (1 minute) • Now, with your table group, develop some sort of visual about the problem-solving process and draw it on the chart paper. (3-5 minutes) • Groups share their diagrams and explain their thinking. (3-5 minutes) • With your group, think about where students in your group may have difficulty with this process and why. On a red sticky note, jot down why this step will be difficult for them. For instance, if you have a student with low reading skills, they might not be able to read the problem, which as our first step. So, you could write down 'low reading skills' and stick it next to step 1. These will be our 'red flags.' (3-5 minutes to complete task)	PPT slide 6 chart paper, texta, red post-it notes
10:05-10:25 (20 min)	Investigating the literature – jigsaw activity • Introduce and set context for the article "Promoting access to common core mathematics for students with severe disabilities through mathematical problem	PPT slide 7

	solving" (i.e., what is CCSSM, what is SBI and its origins) (3 minutes) • Within each group, assign readings: (1) Conceptual Model and Create Access to the Problem, (2) Conceptually Comprehend the Problem, (3) Procedurally Solve the Problem and Generalise Multiple Ways. Allow 5 minutes for reading and note taking. (see handout page 7 for taking notes) • When finished reading: **Pair up with person from opposite group who read same section, outline key points to share with home group. You will have to 'teach' this section to your home group, so be sure you both understand it well.** (3-5 minutes) • **Reconvene with your home group, each person will go over the key parts of their section so everyone in the group understands the entire article. Be sure to ask questions if something is unclear.** (5 minutes) • Share out key points as a whole group (3-5 minutes)	
10:25-10:30	Wrap up • **Looking back at our 'red flags' from the problem-solving exercise, how does SBI support our students to become maths problem solvers? Feel free to pass your post-its around.** Each participant is asked to share one idea.	
10:30-11:00	Morning Tea	
Our MUSEC Research Project: FOCUS *Objective: Participants will provide examples of the four pillars of SBI based on the MUSEC FOCUS research project.*		
11:00-11:45	Present the 2017 FOCUS Study • **We wanted to share our 2017 project with you in more detail to give you the context for the work we will be doing this year. As we do, keep in mind those four pillars of SBI that we just learned about – Create Access to the Problem, Conceptually Comprehend the Problem, Procedurally Solve the Problem and Generalise Multiple Ways. As you hear specific examples of how we did these in our study, jot them down on handout page 8.** • **As a disclaimer, we learned a lot after doing this project and meeting with Dr Saunders, so there are a few things we will do differently this year to improve the intervention.** • Presentation • Ask: **Did anyone find examples of how we created access to the problem? Addressed conceptually comprehending the problem? Procedurally solving the problem? Generalise in multiple ways?**	
11:45-12:00	Introduce the 2018 Professional Development Component • Refer to handout page 9.	

	• Learning cycles – PD Day, weekly 1-1 coaching, fortnightly group meetings (Note: we will schedule these at the end of the day today)
	• Measures for research and reporting
	  o Students: (1) pre-post problem solving assessments, (2) lesson data sheets
	  o Teachers: (1) pre-post survey, (2) fidelity of treatment checklists, (3) artefacts, (4) focus group discussions
	• Preview materials
	  o Hand out binders with lesson plans and materials
	  o Walk teachers through each section
	  o Allow 5 minutes to look at it on their own
	  o These will also be located on the server	

Writing Group Problems *Objective: Participants will write a series of group word problems.*		
12:00-12:15	Writing Group Word Problems • **One thing that would be helpful for all of us as we get started in our classrooms is to have a bank of word problems that we can use with students.** • Review the criteria for writing word problems from the Spooner, et al article. • Look at sample question set. • Think-pair-share: Do these questions meet the criteria set forth in the article? (Give specific examples) How would you improve them? • **On a palm card, write one more question that could go with this question set. Challenge yourself to write one with a missing addend.** • Everyone shares out their problem and all problems are collected to add to the problem bank.	Sample questions on ppt, palm cards
12:15-12:30	Developing Math Story and Corresponding Group Word Problems • Introduce task: **With a partner, develop a maths story/theme and 6 questions to go with it. Think about including a variety of questions that increase in difficulty. Try to include a few missing addend questions.** • Pair up according to class, area teaching (e.g., money problems), etc • Using template in handout, develop math story and corresponding problems. • Turn in before heading to lunch.	Writing group word problems handout
12:30-1:15	Lunch	
FOCUS Lesson Practice		

Objective: Participants will: (1) collect fidelity of treatment data when observing a schema-based instruction lesson; and (2) demonstrate a schema-based lesson to peers		
1:30-2:30	Model and Guided Practice Stage 1 • This afternoon, we will be looking more closely at the lessons and practicing with the lesson scripts. • I will model the first few lessons for you so you can get a flavour of what the intervention looks like. You will use the fidelity of treatment checklist to tick off each lesson component as it occurs. Copies of the fidelity of treatment checklists are on page 10 of your handout packet. • Teacher models the first lesson with the small group. After the lesson finishes, ask the observers: Which components did we complete? Are there any we missed? What questions do you have about that lesson? • Repeat the process with brief models of lesson 2 and 3. Choose different participants and observers for each lesson. • Divide teachers into grade level teams. One teacher acts as the instructor while the others take fidelity of treatment data and act as students. Different participants take the teacher role for each lesson. The facilitator floats around and can offer suggestions during the practice.	
2:30-2:35	Wrap Up • How did the lessons go? • How did you go with the fidelity of treatment checklists? • What questions do you have?	
Getting Started *Objective: Participants will score a pre-assessment using the FOCUS data collection tool.*		
2:35-2:50	Administering the assessment • Introduce the pre-assessment and demonstrate how to administer it • Turn to page 16 in your handouts. We are going to watch a video of a student taking a similar assessment and practice scoring it. This is a video from last year, so it is looking at a different problem type, but you should still see all the parts of FOCUS. When you are finished, we will compare our ratings. • Watch video while teachers code. When finished review ratings for each item and calculate total score.	Video of assessment
2:50-2:55	Getting Started • Review the timeline of 6 week learning cycle • Select dates for group meetings • Select days/times for coaching meetings	
2:55-3:00	Final reflection • On the last page of your handouts (pg. 17), you will find a 3-2-1 reflection. Please take a few minutes to complete this before you go. We will not share it with everyone, it is just for you to consolidate your thinking from the day.	

Working Mathematically Outcomes

EARLY STAGE 1	STAGE 1	STAGE 2	STAGE 3
Communicating MAe1-WM describes mathematical situations using everyday language, actions, materials and informal recordings	Communicating MA1-1WM describes mathematical situations and methods using everyday and some mathematical language, actions, materials, diagrams and symbols	Communicating MA2-1 WM uses appropriate terminology to describe, and symbols to represent, mathematical ideas	Communicating MA3-1WM describes and represents mathematical situations in a variety of ways using mathematical terminology and some conventions
Problem Solving MA3-2WM uses objects, actions, technology and/or trial and error to explore mathematical problems	Problem Solving MA1-2WM uses objects, diagrams and technology to explore mathematical problems	Problem Solving MA2-2WM selects and uses appropriate mental or written strategies, or technology, to solve problems	Problem Solving MA3-2WM selects and applies appropriate problem-solving strategies, including the use of digital technologies, in undertaking investigations
Reasoning MAe-3WM uses concrete materials and/or pictorial representations to support conclusions	Reasoning MA1-3WM supports conclusions by explaining or demonstrating how answers were obtained	Reasoning MA2-3WM checks the accuracy of a statement and explains the reasoning used	Reasoning MA3-3WM gives a valid reason for supporting one possible solution over another

Problem Solving Example

There were some people on a train. 19 people get off the train at the first stop. 17 people get on the train. Now there are 63 people on the train. How many people were on the train to begin with?

What did you do to solve this problem?

-
-
-
-
-

Investigating the Literature

Spooner, F., Saunders, A., Root, J. & Brosh, C. (2017). Promoting access to common core mathematics for students with severe disabilities through mathematical problem solving, *Research and Practice for Persons with Severe Disabilities, 42*(3), 171-186.

Modified Schema-based Instruction (MSBI) Conceptual Model

Create Access to the Problem
Conceptually Comprehend the Problem
Procedurally Solve the Problem
Generalise Multiple Ways

2017 FOCUS Study

Modified Schema-based Instruction (MSBI) Conceptual Model

Create Access to the Problem • Problem development • Problem type selection • Anchoring instruction with thematic problems • Problem structure • Interactive read alouds of math story problems
Conceptually Comprehend the Problem • Modifying traditional SBI for students with severe disabilities • Progression through problem types
Procedurally Solve the Problem • Task analysis • Explicit instruction and systematic instruction • Error correction • Planned fading of behaviour-specific praise • Other evidence-based strategies for students with severe disabilities
Generalise Multiple Ways

2018 Professional Development

Learning Cycles

- 6 weeks
- Driven by coaching plan with individualised goals for teachers and students

Professional Develpment Day

- Introduction to MSBI and FOCUS

1:1 Coaching

- Weekly for 6 weeks
- Focus on individual teacher needs
- Consists of co-planning, the lesson, and debrief

Group Meetings

- Fortnightly for 6 weeks
- On-going training in MBSI
- Consists of one meeting and 'homework'

Measures

Students

- ☐ Pre and post test of maths problem solving
- ☐ Lesson data sheets

Teachers

- ☐ Pre and post survey
- ☐ Fidelity of treatment checklists with notes
- ☐ Artifacts (e.g., coaching notes)
- ☐ Focus group discussions

Directions for Administering Pre- and Post-assessment

1. Have blocks, number lines or other familiar manipulatives available for the student
2. Read the problem out loud
3. Ask: What kind of problem is it?
4. Ask: How do you know?
5. Student solves problem
6. Reread the question to prompt student to verbally provide the answer

Reflection

3 things that stood out to me today 1. 2. 3.
2 questions I have for Sara and Sally 1. 2.
1 thing I will do this week to get ready to teach group problems 1.

Appendix I: Day One Handouts

FOCUS: Modified Schema-based Instruction for Maths Problem Solving

MUSEC School Staff Professional Development

2018

<u>Agenda and Outcomes</u>

Working Mathematically Outcomes in the NSW Syllabus

> *Objective: Participants will explain the three working mathematically outcomes in the NSW Mathematics Syllabus.*

Introduction to Schema-based Instruction

> *Objectives: Participants will (1) explain the four pillars of the SBI model, and (2) identify the features of the three types of addition and subtraction word problems*

Morning Tea

FOCUS: Our MUSEC Research Project

> *Objective: Participants will provide examples of the four pillars of SBI based on the MUSEC FOCUS research project.*

Writing Group Word Problems

> *Objective: Participants will write a series of group word problems.*

Lunch

FOCUS Lesson Practice

> *Objective: Participants will: (1) collect fidelity of treatment data when observing a schema-based instruction lesson; and (2) demonstrate a schema-based lesson to peers*

Getting Started

> *Objective: Participants will score a pre-assessment using the FOCUS data collection tool.*

Appendix J: Coaching Plan

FOCUS Coaching Plan

Teacher ______________________________ Coach ____________________________

Group Meeting Day and Time ____

Teacher and Coach Weekly Planning Time _____________________________________

Student Learning Objective: Students will solve (group/compare/change) problems using the FOCUS strategy.

Teacher Learning Goals	Student Learning Goals
• Conduct a pre-assessment with each student • Follow scripted lesson plans • Collect student data to make instructional decisions • Use levelled prompting during guided practice • Write word problems to use during the lesson • Plan a mini-lesson to address student misunderstandings • Conduct a post-assessment with each student	• State the rule for the problem type • Accurately tell a maths story given manipulatives or a picture prompt • State the components of FOCUS • Solve word problems using FOCUS • Check off steps as completed on a FOCUS self-monitoring checklist • Accurately solve word problems without the aid of the graphic organiser or FOCUS checklist

Appendix K: Weekly Coaching Notes

Weekly Coaching Session Notes

Teacher: Coach:
Meeting date:

Analysing Student Work	
What student work did you analyse?	
What can students do/what do they know?	What are students struggling with?
Planning for the Next Lesson	
How will you address these misunderstandings?	What support do you need from the coach?
	What data will you collect to know if students have learned the material?
Target lesson day/time	Coach role

Appendix L: Research Team Biographies

Dr Alicia Saunders, is the Research Associate for the TIES Center: Increasing Time, Instructional Effectiveness, Engagement, and State Support for Inclusive Practices for Students with Significant Cognitive Disabilities (SwSCD) at the University of North Carolina at Charlotte. Dr Saunders is an adjunct professor. Her research focuses on access to the general curriculum for students with low incidence disabilities and autism spectrum disorder, specifically in the content areas of mathematics and science. Dr Saunders has published several articles and book chapters on general curriculum access and alignment, and has presented on this topic at international and national conferences and in-service trainings for teachers. She is one of the co-authors of *Early Numeracy*, *Math Skills Builder,* and *Access Algebra,* mathematics curricula for students with intellectual disabilities.

The work of Dr Saunders informed much of MUSEC's two-year project. In 2017 AIS project funds were used to bring Dr Saunders to Sydney. While here she implemented MSBI lessons in each of the MUSEC classrooms and met with all teachers to discuss key aspects of effective SBI. Her contribution left teachers enthused about the possibilities of SBI in the MUSEC context. In 2018 Dr Howell and Dr Mills visited North Carolina and observed MSBI being implemented in different special education settings. During this trip Dr Howell and Dr Mills met with Dr Saunders and other special education academics and teachers. The time spent in North Carolina informed aspects of Stage 2 of the project.

Dr Mark Carter is an Associate Professor in special education at the Macquarie University. He has over 30 years of experience in the area of special education, and has published approximately 100 peer-refereed articles. He has a range of research interests including educational issues in autism spectrum disorders, social interaction and friendships in individuals with disability, evidence-based practice in special education and controversial practices. Associate Professor Carter has extensive experience and expertise in research design. He provided advice regarding the design of Study A and Study B.

Ms Betty Ho is a PhD student in special education with around 10 years of working experience in special education settings including four years in observing and coding classroom behaviours of both teachers and students. She collated and coded all student and teacher data, conducted data analysis and prepared graphs and figures for inclusion in project reports and presentations.

Dr Sally Howell, Principal MUSEC and Project Team, has been involved in the education of children with special needs as a teacher and special education consultant for over 30 years. She has worked as a special education lecturer in the areas of effective mathematics instruction and behavior management at Macquarie University and is currently the principal of MUSEC School. Her previous research has focused on early number sense as a predictor of mathematics difficulties. Dr Howell has provided advice to ACARA on the Literacy and Numeracy Learning Progressions and on the role of phonics in early reading instruction. She is the special education representative on the NESA Curriculum Committee.

Dr Sara Mills, Master Special Educator and Project Team Member (Project Leader Stage 2), has over 15 years of experience teaching students with disabilities in both inclusive and self-contained settings. As a Master Special Education Teacher at MUSEC School, she teaches a class of primary-aged students with autism, intellectual disabilities and other language-based disorders. Prior to joining the MUSEC staff, Dr Mills worked in professional development with first year teachers, instructional coaches and school administrators. Her research has focused on strategy instruction for writing and, more recently, mathematics.

Acknowledgements

MUSEC acknowledges the support and assistance received from AISNSW throughout the project, including funding support and advice from the AISNSW research team. We thank Dr Saunders, our mentor and critical friend who provided inspiration for our project and to MUSEC teachers through her demonstration lessons. She was generous with her time and her expertise. We thank Dr Mark Carter for his advice regarding ‘small n’ research and Betty Ho, our research assistant. Thanks also to MUSEC teachers for their enthusiasm during Stage 2.

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