

Feasibility study of the Strength in Numbers program in secondary school classrooms

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Registration: Australian New Zealand Clinical Trials Registry - ACTRN12625000035426

ABSTRACT

Background

Mathematics anxiety and disengagement are growing concerns in secondary education and are linked to poorer academic outcomes. This study examined the feasibility of the Strength in Numbers program, a classroom-based intervention integrating resistance training with mathematics instruction.

Methods

We conducted a single-arm feasibility study in one secondary school in New South Wales, Australia. Two Year 9 mathematics classes ($n = 50$ student; mean age 14.7 years) participated in a 3-week intervention involving brief, curriculum-aligned classroom-based resistance training sessions delivered twice weekly via video. Four prespecified progression criteria related to recruitment, dose delivered, acceptability, and fidelity were the primary outcomes. These outcomes, along with teacher capability, opportunity, and motivation, were examined using teacher surveys and session observations.

Results

All four progression criteria were met. Recruitment exceeded targets (86% consent), both teachers delivered all six planned sessions, and both teachers agreed that the program was acceptable ($M = 4$, $SD = 0.0$). Fidelity was supported by high completion rates for assessments of on-task behaviour (93%), acute mathematics anxiety (78%), chronic mathematics anxiety (72%), and teacher outcome measures (100%).

Conclusion

The Strength in Numbers program may be feasible to implement in secondary mathematics classrooms. A larger controlled trial with refinements to intervention delivery is warranted.

49 **Trial registration**

50 Australian New Zealand Clinical Trials Registry (ACTRN12625000035426).

51

INTRODUCTION

Concerns have been raised globally regarding declining mathematics performance, reduced classroom engagement, and increasing levels of mathematics anxiety among secondary school students (Larsen, 2024). In Australia, mathematics achievement has declined steadily since the early 2000's, while school engagement, a key predictor of academic achievement, also decreases throughout adolescence (Skinner & Pitzer, 2012; Thomson, 2020). Alongside these trends, mathematics anxiety, characterised by feelings of tension and apprehension when engaging with mathematical tasks (Dos Santos Carmo et al., 2019), has emerged as a significant barrier to learning. Higher levels of mathematics anxiety are consistently associated with lower mathematics achievement, reduced mathematical confidence, and avoidance of mathematics related subjects and career pathways (Li et al., 2021). Meta-analytic evidence demonstrates a moderate negative association between mathematics anxiety and performance ($r = -.34$) (Nelson & Powell, 2018), with elevated anxiety disrupting working memory processes essential for problem solving. Interventions that can simultaneously enhance behavioural engagement and reduce anxiety may therefore improve learning outcomes in secondary mathematics (Ashcraft et al., 2022; Biddle et al., 2019; Lubans et al., 2016).

Classroom-based physical activity is a promising strategy for supporting scholastic performance in school settings (Reyes-Amigo et al., 2025). Scholastic performance encompasses both overall academic achievement and subject-specific outcomes, such as mathematics performance. Evidence suggests that even a single bout of physical activity can significantly improve overall scholastic performance ($ES = 0.35$) and mathematics performance ($ES = 0.29$) (Muntaner-Mas et al., 2024). However, it is important to note that most of the existing evidence has been generated from studies conducted in primary schools.

77 The positive effects of classroom-based physical activity on scholastic
78 performance are likely to occur through a range of overlapping behavioural, psychosocial,
79 and neurobiological mechanisms (Lubans et al., 2016; D. R. Lubans et al., 2021). In
80 regard to behavioural mechanisms, classroom-based physical activity interventions have
81 been shown to improve students' time-on task" or "on-task behaviour", which is
82 important for learning in scholastic achievement A range of psychosocial mechanisms
83 may also explain the benefits of classroom-based physical activity interventions, such as
84 arousal and engagement Neurobiological mechanisms explaining the effects of physical
85 activity on scholarship performance, increased cerebral blood flow (Szuhany et al., 2015),
86 increased brain-derived neurotrophic factor (BDNF), and improved white matter tract
87 integrity (Valkenborghs et al., 2019).

88 Despite the extensive benefits of classroom activity breaks, teachers frequently
89 report barriers to their implementation, including time constraints, curriculum pressures,
90 limited resources, and concerns about classroom management (Michael et al., 2019).
91 These challenges are amplified in mathematics classrooms which traditionally do not
92 involve movement, and where instructional time is tightly structured and academic
93 expectations are high. One potential solution is the integration of physical activity
94 delivered with curriculum content. Academic–physical activity integration embeds
95 subject matter within movement tasks, reducing perceptions of lost instructional time and
96 increasing curricular relevance (Lander et al., 2024). While integrated models have been
97 explored in preschool and primary settings (M. F. Mavilidi et al., 2020; Mavilidi et al.,
98 2022), evidence in secondary schools, particularly within mathematics, is lacking (Fenesi
99 et al., 2022).

100 Strength in Numbers is a classroom-based intervention that integrates brief
101 muscle-strengthening activities with mathematics learning through syllabus-aligned

numeracy questions and resistance-based movements performed at students' desks. The primary aim of this study was to examine the feasibility of implementing the Strength in Numbers program in secondary school mathematics lessons. We assessed feasibility across recruitment, dose delivered, acceptability, and fidelity. Our secondary aim was to explore effects on mathematics anxiety and on-task behaviour. The study was not powered to detect definitive treatment effects; rather, we assessed secondary outcomes to determine evidence of promise and to inform progression criteria and sample size calculations for a future effectiveness trial.

METHODS

Design

The Strength in Numbers trial was a single arm feasibility study. Approval to conduct the study within schools in the Catholic Diocese of Maitland–Newcastle was obtained following the diocesan research approval process (approval granted May 2025). The diocesan mathematics lead recommended three schools that had not previously participated in research. Head teachers from these schools ($n = 3$) were invited to participate via email. One school agreed to participate, representing 33% of the schools approached. Eligible participants were students studying mathematics in Year 9 or 10. From the one school, we recruited two Year 9 classes. In total, 50 students were recruited to the study. Teachers of these classes were recruited to deliver the intervention.

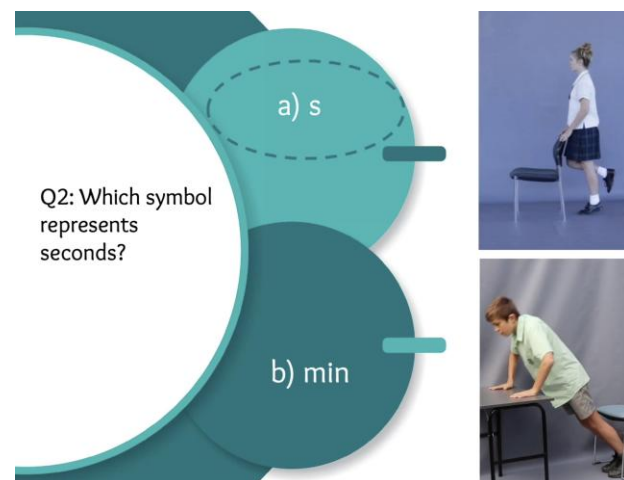
Ethics approval for the study was obtained from the University of Newcastle, Australia (Approval No: H-2025-0007) and the Catholic Schools Diocese of Maitland-Newcastle. The trial was prospectively registered with the Australian New Zealand Clinical Trials Registry: ACTRN12625000035426 and has a Universal Trial Number: U1111-1316-4841. Baseline assessments were conducted in October 2025 and evaluation

continued throughout the intervention until the post-test follow up in December 2025. The design, conduct, and reporting of this study adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Lancaster & Thabane, 2019) and utilised the CONSORT extension for pilot and feasibility trials, with adaptations for non-randomised studies (Eldridge et al., 2016).

Intervention

The Strength in Numbers intervention was delivered during timetabled Stage 5 mathematics lessons over a 3-week period (October 2025 – November 2025). Strength in Numbers was adapted from earlier work from D. Lubans et al. (2021) and Robinson et al. (2022) and consists of brief, five-minute curriculum-aligned movement videos delivered using a HIIT protocol (8 rounds of 20 seconds exercising, 10 seconds rest. Total 4 minutes) at the beginning of mathematics lessons aiming to improve students on-task behaviour and acute and chronic maths anxiety. Each video integrates syllabus-aligned numeracy questions from the Australian Curriculum for students' year level with structured muscle-strengthening activities that can be performed at students' desks without specialised equipment. Students responded to mathematics questions by performing resistance-based movements (e.g., squats, lunges, desk push-ups, isometric holds) to indicate their selected answer (Figure 1). The design prioritises minimal classroom disruption, requires no additional equipment, and aligns with existing teaching programs.

Figure 1. Example of a Strength in Numbers lesson starter delivered within a secondary mathematics classroom



Implementation of the Strength in Numbers program was guided by the Consolidated Framework for Implementation Research (Damschroder et al., 2020). The implementation strategies were designed to align with the CFIR domains by considering the intervention characteristics, school context (inner and outer settings), teacher capability, and the implementation process. More specifically, the intervention was supported by a 2-hour structured professional learning session for participating teachers, which provided (i) rationale for classroom-based movement, (ii) demonstration of exercise technique, (iii) outline of implementation procedures, and (iv) a chance to clarify safety considerations. Teachers were encouraged to deliver two videos per week during the intervention period. Ongoing support was provided by the research team to address implementation questions and monitor adherence. Each session, teachers started their lesson with their normal routine such as greeting students and marking the roll before instructing students to stand. Teachers opened the video provided as a digital link and students participated in the intervention. An example of a video used in the intervention is provided as Online Resource A.

Theoretical framework

The Strength in Numbers intervention was informed by Self-Determination Theory (SDT), which proposes that motivation and engagement are enhanced when three basic psychological needs are supported: autonomy, competence, and relatedness (Deci & Ryan, 2012; Ryan & Deci, 2020). Within mathematics education, supporting students' basic psychological needs has been associated with greater engagement, persistence, and positive mathematical dispositions (Hubbard et al., 2026). Strength in Numbers was designed to support autonomy through meaningful individual participation in integrated movement tasks, competence through achievable mathematics and physical activity challenges, and relatedness through whole-class participation. By embedding brief muscle-strengthening activities within existing mathematics lessons, the intervention aimed to enhance student engagement without reducing instructional time.

Measures

Assessments were conducted at baseline *October 2025*, throughout the delivery of the intervention and at post-test in *November 2025* by members of the research team.

Feasibility outcomes

Criteria for progression to a full-scale trial was used to inform a decision on whether and how to proceed. Each progression criterion (PC) is outlined below. Criteria were established a priori by the research team and informed by Robinson and colleagues (2022). Feasibility outcomes were assessed using teacher surveys, along with implementation measures including teacher checklists and session observations collected during program delivery (Online Resource B). Where criteria fall within the review range, adaptations to the intervention and study procedures will be considered before deciding whether to progress to a future efficacy trial.

PC 1. Recruitment: At least 40% of children in the selected mathematics classes returned consent forms, which required signatures from both parents and children. Review: 0–39%. PC 2. Dose Delivered: The teachers delivered 75% of the expected sessions for the program, averaging 1.5 sessions per week. Proceed: 75% or more; Review: 0–74%. PC 3. Acceptability: Teachers agree or strongly agree that the program is acceptable. Proceed: 75% or more; Review: 0–74%. PC 4. Fidelity: Both classes are retained throughout the study. At least 75% of assenting participants complete all outcome measures. Proceed: 75% of students complete baseline and post-test measures; Review: 0–74% of participants complete. Teacher feedback was collected using an adapted COM-PASS questionnaire to evaluate intervention acceptability and inform future program refinement. The implementation evaluation was informed by the Capability, Opportunity, Motivation–Behaviour (COM-B) model (Michie et al., 2011), which proposed that behaviour is influenced by individuals' capability, opportunity, and motivation. The program assessed teachers' perceived capability, opportunity and motivation to deliver the Strength in Numbers program using the Capability, Opportunity and Motivation to deliver Physical Activity in School Scale (Verdonshot et al., 2024).

Student outcomes

Standard demographic information was collected at baseline and administered via a paper survey. Socioeconomic backgrounds were determined by population decile using socioeconomic indexes for areas (SEIFA) of relative socioeconomic disadvantage based on residential postcode.

On-task behaviour was assessed using momentary time sampling adapted from the *Behavior Observation of Students in Schools* and *Applied Behavior Analysis for Teachers* (Alberto & Troutman, 2013). Two research assistants observed the same six randomly selected students during each session. Attendance was confirmed during the first 10

minutes; absent students were not replaced. Immediately following the Strength in Numbers session, observations were conducted at 15-second intervals on a rotational basis over 30 minutes. Using synchronised stopwatches, observers coded behaviour as on-task (active or passive) or off-task (motor, verbal, or passive). Scores were calculated as the percentage of observed intervals spent on-task or off-task. Inter-rater reliability for this protocol has previously been established ($ICC = 0.84$; (Mavilidi et al., 2021)).

Acute mathematics anxiety was measured using a brief survey administered via QuestionPro immediately before and after each Strength in Numbers session. The survey was adapted from the Acute Mathematics Anxiety Scale (Ersozlu, 2026). The survey included three items assessing: (i) how students were feeling before the mathematics lesson, using a three-point scale ranging from “nervous” to “excited”; (ii) readiness to learn, using a four-point scale ranging from “not ready” to “very ready”; and (iii) confidence prior to the lesson, using a four-point scale ranging from “not at all confident” to “very confident”. An increase in score indicates improvements across all items.

Chronic mathematics anxiety was assessed at baseline and post-test (3 weeks). The survey had an introductory question asking students to rate their mathematics ability from not successful, somewhat successful or very successful. The next ten questions assessed chronic maths anxiety using the Mathematics Anxiety Rating Scale (Betz, 1978), administered in hard-copy format. The survey is a validated self-report instrument designed to measure trait-like anxiety associated with mathematics learning. Participants complete the questionnaire during scheduled class time under standardised conditions. Items are rated on a Likert scale (ranging from 5= “*Strongly agree*” to, 1= “*Strongly disagree*”). We adapted the survey to ensure higher scores indicated lower levels of chronic mathematics anxiety.

Statistical analysis

Teacher survey questions relating to recruitment, dose delivered, acceptability, and fidelity were summarised using descriptive statistics including frequencies, percentages, means, and standard deviations where appropriate using R version 4.6.0. Recruitment was calculated as the percentage of students returning signed consent forms relative to the total number of eligible students within participating classes. Dose delivered was calculated as the proportion of completed Strength in Numbers sessions relative to the total number of planned sessions across the intervention period. For each class, the mean and standard deviation were calculated from session observation scores. Teacher survey data were summarised descriptively using mean and standard deviation (SD). Capability, opportunity, and motivation domain scores were calculated by averaging the relevant survey items for each teacher before calculating the overall mean (SD) across respondents. Acceptability was assessed using a single survey item and reported as the mean (SD). Fidelity outcomes were analysed descriptively and reported as frequencies, percentages, and completion rates for class retention, participant completion of outcome measures, and teacher participation in data collection.

As this was a single arm feasibility study without a control group, student outcome analyses were exploratory and used within group pre post comparisons to provide preliminary estimates of change and inform the statistical approach for a future efficacy trial. Acute on task behaviour outcomes were summarised descriptively using the mean proportion of observed intervals coded as on task or off task across sessions. Changes in student chronic mathematics anxiety were analysed using paired sample t-tests to determine mean change from baseline to post-test, and from pre session to post session for acute mathematics anxiety outcomes. Means, standard deviations, mean differences, 95% confidence intervals and *p* values were reported where appropriate.

RESULTS

Figure 2 shows the flow of participants through the study. Students baseline characteristics are presented in Table 1. A total of 50 students (14.7 ± 0.46 years, 52% female) completed baseline assessments. Most students identified as Australian (84%) or Asian (18%), and approximately 90% of students were from low socioeconomic backgrounds (i.e., SEIFA decile ≤ 3).

Figure 2. Flow diagram of participants

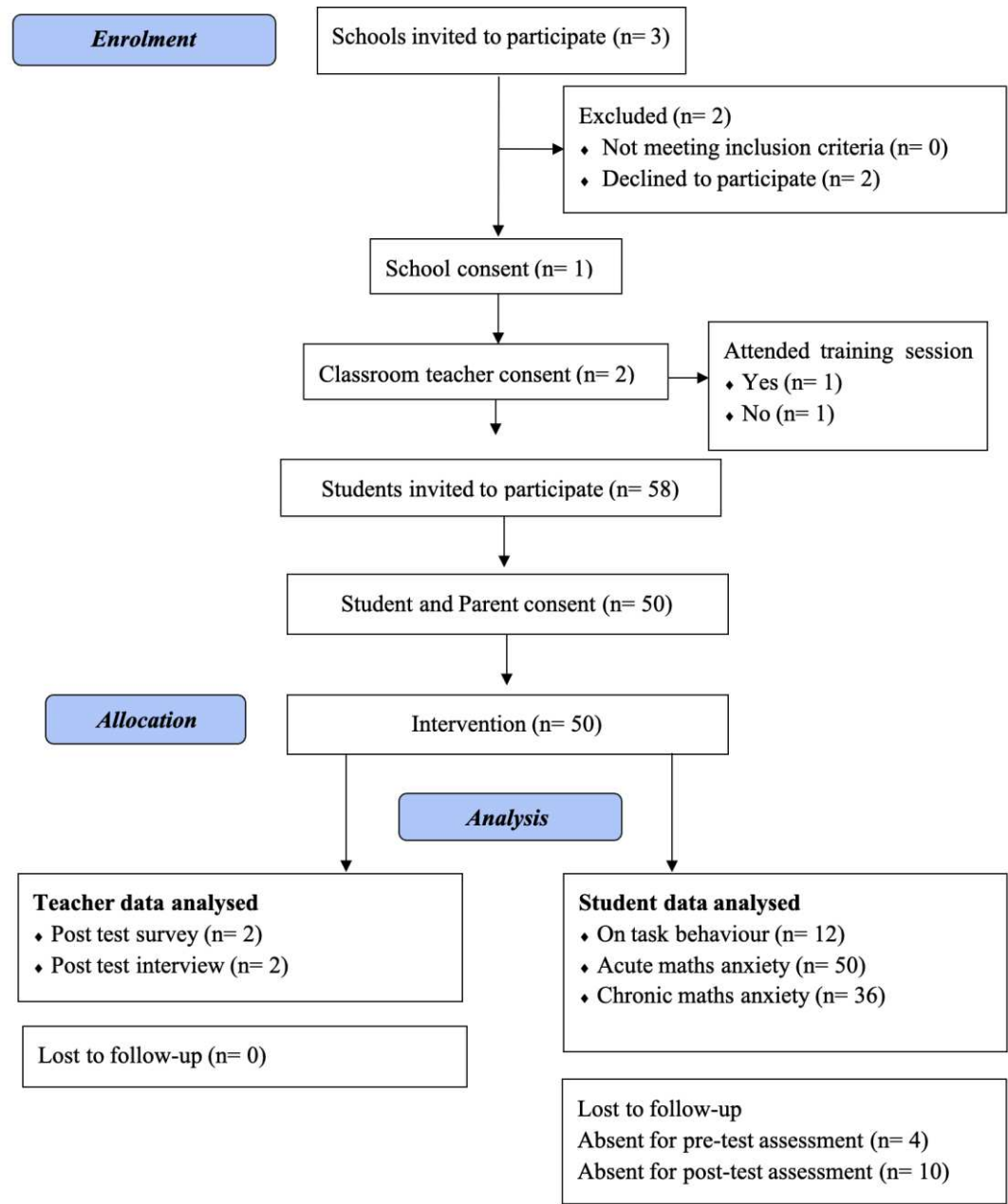


Table 1. Descriptive characteristics of study participants.

Students	(n=50)
Age, mean (SD) years	14.7 (0.46)
Sex, n (%)	
Male	23 (46)
Female	26 (52)
No response	1 (2)
Socio economic status, n (%)	
1 Most disadvantaged	2 (4)
2	43 (86)
3	4 (8)
4	0 (0)
5 Most advantaged	0 (0)
No response	1 (2)
Aboriginal or Torres Strait Islander, n (%)	
Yes	2 (4)
No	48 (96)
Cultural background ^a , n (%)	
Australian	42 (84)
African	1 (2)
Asian	9 (18)
European	2 (4)
Teachers	(n=2)
Sex, n (%)	
Male	2 (100)
Cultural Background, n (%)	
Australian	2 (100)
Age, n (%)	
35 - 44 years	2 (100)
Aboriginal or Torres Strait Islander, n (%)	
No	2 (100)
Current role	
Permanent Mathematics teacher	2 (100)
Teaching experience	
1-5 years	1 (50)
11-15 years	1 (50)

^a Students could provide more than one response to this question.

Feasibility outcomes

All four pre-specified progression criteria were met.

PC 1. Recruitment: Participant information and consent forms were distributed to 58 students, with 50 students returning signed consent forms (86% consent rate). Two male mathematics teachers ($n = 2$) agreed to participate in the study. Teaching experience ranged from 1–5 years ($n = 1$) to 5–11 years ($n = 1$). One teacher attended the intervention training session and subsequently briefed the second teacher. Both teachers delivered the Strength in Numbers intervention to their Year 9 mathematics classes ($n = 2$ classes; $n = 50$ students).

PC 2. Dose Delivered: Teachers delivered the planned intervention dose of six sessions (two sessions per week for three weeks). Session observations were conducted by a research assistant and are reported in Table 2. Minor logistical challenges were observed during session observations, including room configuration, internet access for surveys, and audio balance between music and instructions, which occasionally slowed student response to questions. When lower student motivation was noted, observations suggested that some questions may have been too challenging and that limited response time may have reduced student responses.

Table 2. Session observations for the Strength in Numbers intervention across six sessions in two Year 9 mathematics classes.

Observation questions	Class A Mean (SD) ^a	Class B Mean (SD) ^a
Students accessed the acute Maths Anxiety questions online before starting the video	4.33 (0.52)	4.5 (0.55)
Students accessed the Acute Maths Anxiety questions online after completing the video	4.50 (0.55)	4.17 (0.75)
Students put the device away quickly and prepared for the lesson.	4.33 (0.82)	4.83 (0.41)

The teacher played the video within the first 10 minutes of the lesson.	3.83 (1.17)	4.17 (0.75)
The videos were easy to access, loaded quickly and played as intended.	4.83 (0.41)	5 (0)
Teacher had to use the USB back up to play videos	5 (0)	5 (0)
The maths questions were achievable for all students in the class	4.67 (0.52)	3.17 (0.98)
Students had sufficient room to safely complete all required exercises	4.33 (0.52)	4.5 (0.84)
The timing on the video promoted engagement	4.67 (0.52)	3.83 (0.75)
Students appeared actively engaged during the videos	4.5 (0.55)	2.5 (0.55)
Students remained on-task throughout the video	4.83 (0.41)	2.5 (0.55)
Students appeared to enjoy the stimulus video	3.83 (0.75)	2.17 (0.75)

^a Values are presented as mean (SD). Items were rated on a 5-point Likert scale, where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. Higher scores indicate more favourable observations of intervention delivery.

PC 3. Acceptability: Both teachers agreed that the program was acceptable overall (M = 4, SD = .00). Ratings for the video quality (M = 2.5, SD = .12) and mathematics questions (M = 3, SD = 1.41) were less acceptable (Table 3).

Table 3. Teacher survey outcomes related to feasibility and progression criteria

Feasibility domain	Results ^a
	Mean (SD)
Acceptability	4 (0)
Capability	4.25 (0.35)
Opportunity	3.93 (0.10)
Motivation	3.58 (0.12)

^a Values are presented as mean (SD). Capability, opportunity, and motivation scores were calculated by averaging the relevant survey items for each teacher before calculating the mean (SD) across respondents. Acceptability was assessed using a single survey item ("Strength in Numbers is acceptable to me"). Scores were rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with higher scores indicating more favourable perceptions of intervention feasibility.

PC 4. Fidelity: Both classes were retained throughout the study. 93% of assenting participants completed on task behaviour measures. A total of 234 responses of acute maths anxiety were recorded across six sessions (78%) and chronic maths anxiety responses had a 72% completion rate. There was 100% completion rate for teacher participation in outcomes measures.

Teachers reported high capability ($M = 4.25$, $SD = .35$) and opportunity ($M = 3.93$, $SD = .10$) to deliver the intervention, while motivation was slightly lower but remained positive ($M = 3.58$, $SD = .12$).

Student outcomes

On Task Behaviour

Time-on-task data were recorded for two classes (Table 4). On task behaviour differed between classes, with students in Year 9A demonstrating a higher proportion of time on task (76.4%) compared to Year 9B (52.8% on task).

Table 4. On task behaviour results reported in class groups

Class	Number of participants	Mean percent of time on task	Mean percent of time off task
Year 9A	12	76.4%	23.6%
Year 9B	12	52.8%	47.2%

Acute Maths anxiety

Acute mathematics anxiety outcomes demonstrated small but statistically significant improvements following participation in the Strength in Numbers sessions (Table 5). Students reported feeling more positive towards mathematics (Cohens $d = .24$, 95% CI's = .06 to 0.20, $p = < .001$), greater readiness to learn (Cohens $d = .24$, 95% CI's = .07 to .24, $p = < 0.001$) and increased confidence prior to mathematics lessons (Cohens $d = .27$, 95% CI's = .10 to .28, $p = < .001$).

Table 5. Acute mathematics anxiety outcomes before and after participation in each Strength in Numbers sessions.

	n	Pre session Mean (SD)	Post session Mean (SD)	Mean Change score (SD)	95% CI	P value	Cohen's d
Feelings towards mathematics	234	2.06 (0.39)	2.19 (0.44)	0.13 (0.54)	0.06 to 0.20	<0.001	0.24
Readiness to learn mathematics	234	2.81 (0.69)	2.97 (0.66)	0.16 (0.66)	0.07 to 0.24	<0.001	0.24
Confidence prior to mathematics	234	2.77 (0.71)	2.96 (0.72)	0.19 (0.71)	0.10 to 0.28	<0.001	0.27

Note: Positive change scores indicate improvements from pre session to post session responses.

311

312 *Chronic Maths Anxiety*

313 A mean score of 2.25 at post-test indicated that, on average, participants perceived
 314 themselves as between somewhat successful and very successful in mathematics. There
 315 was a small reduction in maths anxiety for students' feelings of ease during maths tests
 316 (Cohens d = 0.33, 95% CI's = 0 to 0.78, $p = .051$). Complete data sets were analysed and
 317 are reported in Table 6.

Table 6. Chronic Maths anxiety results

Students	n	Baseline Mean (SD)	Post test Mean (SD)	Mean Change score	95% CI	P value	Cohens d
Rate your ability in maths	36	2.25 (0.50)	2.28 (0.51)	0.03	-0.1 to 0.16	0.661	0.05
It wouldn't bother me at all to take more maths classes.	36	3.25 (1.05)	3.33 (1.10)	0.08	-0.36 to 0.53	0.707	0.08
I have usually been at ease during maths tests.	36	2.86 (1.27)	3.25 (1.00)	0.39	0 to 0.78	0.051	0.33
I have usually been at ease in maths courses.	37	3.46 (0.96)	3.38 (0.86)	-0.08	-0.35 to 0.18	0.539	-0.09
I usually don't worry about my ability to solve maths problems.	37	3.14 (1.08)	3.16 (1.09)	0.03	-0.29 to 0.35	0.865	0.02
I almost never get uptight while taking maths tests.	36	3.08 (1.27)	2.97 (1.18)	-0.11	-0.52 to 0.3	0.586	-0.09
I get really uptight during maths tests.	37	3.19 (1.35)	3.19 (1.22)	0.00	-0.33 to 0.33	1.000	0.00
I get a sinking feeling when I think of trying hard maths problems.	36	3.08 (1.27)	3.28 (1.14)	0.19	-0.14 to 0.53	0.242	0.16
My mind goes blank, and I am unable to think clearly when working on mathematics.	37	3.62 (1.19)	3.41 (1.07)	-0.22	-0.56 to 0.13	0.210	-0.19
Mathematics makes me feel uncomfortable and nervous	36	3.83 (1.16)	3.86 (1.20)	0.03	-0.25 to 0.3	0.838	0.02
Mathematics makes me feel uneasy and confused.	37	3.57 (1.28)	3.57 (1.12)	0.00	-0.35 to 0.35	1.000	0.00

Discussion

The aim of this study was to examine the feasibility of the Strength in Numbers program within secondary school mathematics classrooms and to explore preliminary changes in student outcomes. Overall, the findings support the feasibility of the program, with progression criteria achieved across recruitment, dose delivered, acceptability, and fidelity. Teachers also reported acceptable levels of capability, opportunity, and motivation to deliver the Strength in Numbers program, although item-level responses identified specific areas for refinement in future intervention delivery. In relation to the secondary aim, preliminary evidence of promise was observed across student outcomes, particularly acute math anxiety. Collectively, these findings support refinement of the program and progression to a larger controlled trial.

Recruitment and school engagement are critical considerations when evaluating the feasibility of school-based interventions (Clayton et al., 2021). In the delivery of Strength in Numbers recruitment targets were achieved. Once school approval was obtained, teacher participation and student recruitment exceeded expectations, indicating interest in alternative approaches to mathematics instruction. Similar recruitment success has been reported in school-based feasibility studies evaluating classroom movement interventions (Walker et al., 2025). In the approach taken by Walker et al., (2025), researchers presented at a district wide leadership convention and after identifying prospective school partners, presented at each school. The connection at a school level, rather than a governance level, is an approach Strength in Numbers should consider in the future to increase recruitment rates for an efficacy trial.

A notable finding was the successful dose delivery of all planned sessions. Time constraints, curriculum demands, and pressure to cover syllabus content are frequently reported as barriers to implementing new practices in secondary classrooms, particularly

in mathematics (Kavanagh et al., 2023; Michael et al., 2019). Despite these challenges, teachers delivered the full intervention dose, suggesting the brief lesson starter format was compatible with existing classroom routines. Teachers also reported that future implementation could be strengthened by aligning mathematics questions more closely with lesson content. This approach would allow teachers to adjust the content and difficulty of questions to better align with students' current focus in class level of understanding. Research suggests that learning is optimised when students are challenged within their zone of proximal development (Young et al., 2024), with tasks that are sufficiently difficult to promote productive struggle but not so difficult that they lead to frustration or disengagement (Kusmaryono & Kusumaningsih, 2021). Emerging artificial intelligence tools could be used in Strength in Numbers, generating mathematics questions aligned to syllabus outcomes and differentiated to meet the needs of individual learners making the program an adaptable pedagogical tool for teachers.

The video format was acceptable to teachers although they identified opportunities to improve the quality. This issue appeared to be influenced by the learning environment, as the intervention was delivered in an open-plan setting where multiple classes shared a common teaching space. Music was included within the videos to support student motivation and engagement during movement activities (Ballmann, 2021). However, teachers were observed reducing the volume to minimise disruption to neighbouring classes. While the verbal delivery of mathematics questions remained important, the feedback suggests that a standardised audio format may not suit all classroom contexts. Instead, teachers may benefit from greater autonomy to modify features such as music, volume, and question delivery to better align with the environment in which the program is being implemented.

When assessing fidelity, we found that both participating classes were retained throughout the study, teacher participation in outcome measures was complete, and completion rates for student outcome measures exceeded 70%. The collection of on-task behaviour data across all intervention sessions was feasible within the current study; however, the resources required to conduct repeated classroom observations would need to increase to be able to manage a larger effectiveness trial. Previous studies have commonly assessed on-task behaviour using pre- and post-intervention observation periods or selected observation windows rather than continuous monitoring throughout an intervention (M. Mavilidi et al., 2020; Mavilidi et al., 2021; Robinson et al., 2022). A reduced observation schedule may provide sufficient information while minimising data collection burden and improving scalability.

School-based physical activity interventions often struggle to achieve sustained implementation, with teachers' capability, opportunity, and motivation recognised as important determinants of program delivery (Verdonschot et al., 2024). To reduce teacher burden, Strength in Numbers was designed as a video-based lesson starter supported by a professional learning session prior to implementation. Teachers reported high levels of capability, opportunity, and motivation to deliver the program; Nevertheless, item-level responses identified several areas requiring refinement. Confidence in engaging students during movement activities was lower than other capability indicators, suggesting the professional learning session could place greater emphasis on strategies to support participation and engagement. This may include demonstrating exercise modifications that accommodate varying levels of student ability, confidence, classroom space, and available equipment. Teachers also highlighted the need for greater flexibility in exercise selection, reinforcing the importance of teacher autonomy when implementing the program across diverse classroom environments. The findings also suggest that

engagement may be strengthened through greater emphasis on the social elements of participation, which have previously been identified as important contributors to enjoyment and adherence in movement-based interventions (Turner et al., 2019).

Although the primary purpose of this study was to evaluate feasibility, student outcomes were explored to assess evidence of promise and inform the design of a future effectiveness trial. Consistent with recommendations for feasibility research, these outcomes were not intended to establish effectiveness, but rather to determine whether the proposed mechanisms warranted further investigation in a larger controlled study (Lancaster & Thabane, 2019).

Changes to on-task behaviour are one of the most robust findings in classroom based physical activity interventions and is considered an important precursor to learning and academic achievement (Watson et al., 2017). In our study, students in Year 9A spent a greater proportion of lesson time on task than students in Year 9B. While a control group was not included, the findings suggest that classroom context may influence how students respond to the intervention. We hypothesise that the results may be linked to findings from the classroom observations which indicate 9B had lower scores question suitability and student engagement during the videos. The impact of cognitive demand combined with classroom resistance training breaks has previously been tested and we found in that study groups with and without cognitive demand showed improvements to on task behaviour (Robinson et al., 2022).

We observed small improvements in students' feelings towards mathematics, readiness to learn, and confidence following participation in the Strength in Numbers sessions. These findings are notable given the intervention lasted only five minutes and were measured immediately before and after participation. The program was designed to support students' readiness for mathematics learning, and the observed changes suggest

that a brief movement-based lesson starter may positively influence how students approach mathematics lessons. Less favourable findings for chronic mathematics were observed. Changes in chronic mathematics anxiety were small, with the largest improvement observed for students' feelings of ease during mathematics tests. Interestingly, during the intervention period students were preparing for a half yearly exam and this may have influenced the reporting on this assessment item. Given the short intervention period, substantial changes in chronic mathematics anxiety were not expected, but mathematics anxiety remained an important concern in secondary education. Research shows that mathematics anxiety is associated with lower mathematics achievement and reduced engagement with learning (Yan, 2024). Recent evidence suggests that mathematics anxiety and achievement may operate in a reciprocal cycle, where increased anxiety contributes to lower achievement and lower achievement further reinforces anxiety (Lau et al., 2024). Improvements in students' feelings towards mathematics, readiness to learn, confidence, and ease during mathematics tests were encouraging and suggest that movement based activities during exam periods could be a useful tool to reduce test anxiety.

This study has several strengths and limitations. A strength of the study was the use of pre-specified progression criteria to guide decisions regarding progression to a larger trial (Mellor et al., 2021). The study design enabled the collection of various types of quantitative data from both teachers and students, providing a detailed understanding of program feasibility and areas requiring refinement. Several limitations should also be acknowledged. First, the intervention was delivered over three weeks and therefore did not reflect how Strength in Numbers is intended to be used in practice. The program was designed as a flexible pedagogical tool that teachers can use in response to student needs rather than as a fixed intervention delivered at prescribed times. Second, the study

involved a single school and two classes, limiting the generalisability of the findings. Third, no control group was included, and student outcomes were exploratory in nature. Finally, the intervention relied on researcher-developed videos, which received lower acceptability ratings and may have influenced student engagement. Despite these limitations, the study achieved all progression criteria and provided important information to guide refinement of the program and study procedures prior to a larger trial.

Future iterations of Strength in Numbers should provide teachers with greater flexibility to select mathematics topics aligned with current lesson content and adjust question difficulty to suit the needs of their students. Teachers should also be provided with options to modify exercises based on classroom space, available equipment, and student preferences. These refinements may improve acceptability, support differentiation, and enhance integration within routine mathematics instruction. Future research should evaluate the effectiveness of the program using a controlled design across multiple schools and over a longer intervention period. In addition to examining mathematics anxiety (Mellor et al., 2021) and engagement outcomes, future studies should determine whether improvements in readiness to learn and on-task behaviour translate to meaningful improvements in mathematics achievement.

Conclusion

The Strength in Numbers program appears to be feasible to implement within secondary school mathematics classrooms and met all pre-specified progression criteria. Preliminary findings support that integrating movement with mathematics instruction may facilitate student engagement and readiness to learn and reduce aspects of mathematics anxiety. With refinement of program content and delivery procedures, a larger controlled trial is warranted to determine the effectiveness of the program.

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475 **Financial or non-financial interests**

476 The authors declare they have no competing interests

477 **Ethical approval:**

478 This project was approved by the University of Newcastle's Ethics committee, Approval
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480 **Contributors**

481 KR, DL, NR, ZE and MM conceptualised and designed the study. KR, RP and GN
482 collected data and KR drafted the initial manuscript. KR carried out the data analyses and
483 all authors reviewed and revised the manuscript. All authors critically reviewed the
484 manuscript, advised on statistical corrections and added intellectual content to the
485 manuscript. All authors approved the final manuscript as submitted and agree to be
486 accountable for all aspects of the work.

487 **Data sharing statement**

488 Data relevant to the study is available on reasonable request to the corresponding author.

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Online resources

Online Resource A – Example of a Strength in Numbers video

<https://vimeo.com/570120840>

Online Resource B – Recruitment strategy assessment tool

		(1 = Strongly disagree to 5 =Strongly agree)				
Approval process	i) The approval process with the Catholic Schools Office was completed within a reasonable timeframe.	1	2	3	4	5
	ii) The approval process was straightforward, with clear guidelines and requirements.	1	2	3	4	5
Teacher engagement	iii) The attendance rate at the Mathematics staff forum presentation was satisfactory.	1	2	3	4	5
	iv) Lead teachers showed interest in the Strength in Numbers program during the presentation.	1	2	3	4	5
	1. The feedback from lead teachers after the presentation was positive.	1	2	3	4	5
Flyers and emails	2. The response rate to the emails and flyers was satisfactory.	1	2	3	4	5
	3. Follow-up efforts (e.g., additional emails or phone calls) effectively increased school engagement.	1	2	3	4	5
School	v) The number of schools agreeing to participate met the targeted goal.	1	2	3	4	5

	vi) The distribution of Participant Information Statements (PIS) and consent forms to students was easily achievable with the support of teachers.	1	2	3	4	5
	vii) A high percentage of students returned signed consent forms within the expected timeframe.	1	2	3	4	5
	viii) School leaders were supportive and cooperative in the recruitment process.	1	2	3	4	5