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Abstract

The use of SAFMEDS cards, which stands for '*S*ay *A*ll *F*ast *M*inute *E*very *D*ay *S*huffled' has been widely reported in the literature as an effective fluency-building tool. Most studies have focused on students with a learning disability or those classed as at risk of failing academically. In addition, most of the research has implemented SAFMEDS one-to-one or in small groups. We investigated the use of SAFMEDS in a high school setting, targeting basic maths skills across the whole class. Forty-eight students aged 11-12 years participated in the study over a 4-week period. Our results showed that using SAFMEDS to compliment students' maths lessons can further increase basic maths skills when compared to standard maths classes alone. We also found that the gains were maintained at a 1 month follow-up. An application quiz showed that students could also transfer the information they had learned to real-world maths problems.

Key words: High School Students, SAFMEDS, Maths, Numeracy, Precision Teaching

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Evidence suggests that early intervention for skill deficits has the best outcomes across a variety of areas of educational intervention (Camilli, Vargas, Ryan, & Barnett, 2010). They also found that the main pedagogical approach was direct instruction, and that this approach can produce increases in skills that can be performed at the same level of mastery event after a prolonged period of time. In the area of maths instruction, early intervention has been shown to remediate early difficulties (Schopman & Van Luit, 1996). Despite the effectiveness of approaches to improving educational skills, there is also evidence that many students reach high school without the basic maths skills they should have acquired in primary school. Statistics show that maths is a particular area of need, especially in the United Kingdom. For example, in 2012 only 33% of students achieved above a B grade for General Certificate of Secondary Education (GCSE) maths (Organisation for Economic Co-operation and Development [OECD], 2012). Maths skills are essential for everyday life, and numerate adults are essential to a thriving economy (Hannover & Kessels, 2004). Many employers require their employees to have a range of maths skills, and employment rate decreases significantly for those not competent in maths (Tariq & Durrani, 2009).

There is ample research into the effectiveness of various maths programmes for primary school children, for example the Numeracy Recovery Scheme (Dowker, 2001, 2005, 2007; Dowker & Sigley, 2010) and Catch up Numeracy (Dowker & Sigley, 2010). Both of these interventions provide 30-min one-to-one individualised learning sessions to increase maths skills. Maths interventions are not restricted to being implemented one-to-one. For example, other research into interventions such as the Peer-Assisted Learning Strategies (PALS; Fuchs & Fuchs, 1998) has shown that class-wide interventions can be successful in increasing basic maths skills. PALS is based on basic instructional principles such as dyadic and class-wide peer tutoring, which is usually implemented three times per week for a 16-

week period. It has been shown that PALS is effective in increasing basic maths skills of primary schools students, both those with and without a learning disability (Fuchs, Fuchs, Yazdian, & Powell, 2002).

Precision teaching (PT) is another approach that has been shown to be highly effective at improving basic skills across a wide range of domains; literacy (e.g., Cavallini, Berardo, & Perini, 2010), numeracy skills (e.g., Brady & Kubina, 2010; Casey et al. 2003; Hayden & McLaughlin, 2004), and daily living skills (e.g., Fabrizio et al., 2007; Twarek, Cihon, & Eshleman, 2010).

Ogden Lindsley and colleagues developed PT with the aim of introducing learning measurement procedures that would enable teachers to make evidence-based and individualised educational decisions for each student (e.g., Lindsley, 1964, 1990). The main components of PT are to (1) to assess a deficit in a skill; and, (2) to provide opportunities for timed practice until mastery has been reached (see the EJOBA special edition on PT for more detailed information, 2003). *S*ay *A*ll *F*ast *M*inute *E*very *D*ay *S*huffled (SAFMEDS) cards have been shown to be an effective tool in increasing basic skills in students (Chiesa & Robertson, 2000; Hughes, Beverley, & Whitehead, 2007). SAFMEDS were developed based on the principles of PT; they allow free operant responding so that the student can respond at their own pace (Lindsley, 1990), provide the student with immediate corrective feedback, provide fluency building practice, and enable learning to be measured relatively easily. The procedure also allows students to record their own learning data, and encourages ownership of their learning (Deci & Ryan, 1987). Immediate and corrective feedback has been shown to benefit student learning (Johnson & Street, 2004). Although providing corrective, immediate, and individualised feedback for the whole class can be difficult, SAFMEDS provide a way for students to receive feedback quickly on each separate fact they are learning (Metcalfe, Kornell, & Finn, 2009). When a person can perform a skill fluently (i.e., under

appropriate stimulus control, quickly, and accurately), the skill can be maintained over a long period of time and easily applied to other situations (i.e., generalisation). Therefore, by including fluency-building methods of learning in classroom instruction, the application of instruction to real-world situations is facilitated (Binder, 1996).

The ability to measure student learning is one of the most powerful tools a teacher or student can have for learning, and remains one of the defining features of effective instructional approaches (Fredrick & Hummel, 2004). By measuring learning, educators can assess whether the child is acquiring new skills and knowledge in an ongoing manner. Standard measures of learning in schools are often conducted at a 'macro level' and are norm- or criterion-referenced (e.g., standardised tests show learning over a school year). Curriculum placement tests are used to place students into specific curricular, and 'meta-level' tests are typically run monthly to monitor student progress (Johnson & Street, 2004). Examples of meta-level tests are reading or maths tests; they are conducted more frequently than macro-level tests but are not ongoing or regular measures of learning (Street & Johnson, 2004). However, both macro- and meta-level measures of learning have their limitations because they do not identify when a student is not acquiring skills and beginning to struggle, or what might be done to help. Micro-level measures (direct, regular assessments of specific skills) can help address the limitations of other levels of assessment, and these may be especially useful for learners who are not achieving what is required of them. PT employs measurement at the micro level, and displays this measurement on graphs to provide a daily 'learning picture' of students' learning (Johnson & Street, 2004). Daily measurements help to ensure that skill deficits are identified as early as possible. It is important to note that merely measuring student learning is not sufficient; educators must react to the students' data. In this regard, PT practitioners use learning pictures to help decide whether the learner is progressing towards the level considered fluent for that skill, and if not, what might be done

to help them learn faster (see Kubina & Yurich, 2012 for a more detailed explanation for the use of learning pictures). PT describes four critical learning outcomes; maintenance, endurance, stability, and application.

The majority of the research using PT has been conducted with individuals with developmental disabilities on a one-to-one basis. A recent review found 55 studies that used PT to support basic skills with students with intellectual disabilities, but only 10 of those targeted numeracy skills (Ramey et al., 2016). To our knowledge there has been little to no research assessing the effectiveness of the use of SAFMEDS on a class-wide basis within a mainstream high school population. Therefore, the purpose of our study was to evaluate the use of SAFMEDS to teach maths skills across a whole high school class. In addition, we focused on two of the four critical learning outcomes in PT. First, we aimed to assess whether students would maintain the information learned after a month of no SAFMEDS intervention in the chosen maths topic (maintenance), and second, whether the students were able to apply the information learned to real-world scenarios (application).

Method

Participants and Setting

Forty-eight high school students (21 male and 27 female) aged 11-12 years participated. The students comprised two Year 7 middle set classes in the same maths ability grouping. We allocated each class randomly to be either to the control or intervention group. For their data to be included in the study, a student was required to complete 90% of the sessions and the pre-, post-, and 1-month follow-up tests. Due to failure to meet the inclusion criteria, six students were removed from each group, and the final analysis consisted of 19 students in the intervention group and 16 students in the teaching as usual (TAU) control group. Sessions were conducted in the student’s classrooms during their maths lesson.

Materials

A timer was used to time the daily sessions and was used for the pre-, post-, and one-month follow-up tests. The students in the intervention group were each given a SAFMEDS pack based on percentages of money, which was created based on the maths curriculum.

Measurement

Tests. Students were given pre-, post-, and 1-month follow up-tests to evaluate their knowledge of maths in the topic area of 'percentage of money.' The topic included the percentages 1-10%, 15%, 25%, 40%, 50%, and 75%. For example, '35% of £40 = _____'. We created application tests based on the SAFMEDS pack that were comprised of 10 scenarios. For example, 'A jumper is for sale for £20 but has a 75% sticker on it. How much will I pay for the jumper?'.

All students in the intervention group were given a sheet on which to record their daily SAFMEDS data and a chart on which to record their best timing of the day. A plastic wallet was provided to each student for their table, chart, SAFMEDS pack, and a pencil.

Design

The intervention used a mixed design in which the between-group variable was the group to which students were assigned (SAFMEDS or TAU), and the within-subject variable was time (pre-, post-, and follow up-tests). The time allocated to learning the maths skills was the same for both groups.

Procedure

Prior to intervention, the first author instructed the teacher in the use of SAFMEDS in the classroom. During intervention, both groups received maths instruction as usual. However, the intervention group received 30 min of instruction followed by an additional 20 min of completing the SAFMEDS session, whereas the control group received 50 min of instruction. SAFMEDS sessions were completed in 1-minute time sprints four times per day, three days a week for four weeks (Mondays, Wednesdays, and Fridays). The first author

attended all of the intervention sessions, observed the students to ensure the procedure was implemented correctly, and provided support when needed.

Pre-tests. Students in both groups (intervention and TAU) completed a pre-test quiz based on the SAFMEDS pack. Students were informed verbally and on the top of the quiz that they were not expected to know the answers as the questions were based on a topic that they had not yet been taught. The instructions given to the students prior completing the pre-test were: (1) the quiz was to be completed in exam conditions (e.g., no talking, only look at your own work); (2) the quiz was to be completed in 10 min (a timer was provided); (3) to write down the time they took to complete the quiz if less than 10 min; and, (4) to put an x in the answer space if they did not know the answer. Following the pre-test, students completed a 10-question application quiz under the same instructions and conditions.

Intervention. Prior to the first SAFMEDS session, three students in the intervention group who had been involved in a pilot study of SAFMEDS met with the first author for 30 min to develop a script. The script explained the rationale, benefits, and step-by-step instructions of SAFMEDS. The students delivered the script to the rest of the intervention group, as well as demonstrating the procedure. Following the demonstration, the intervention group completed a practice session using the SAFMEDS.

The maths instruction at usual preceded the SAFMEDS session for the intervention group and was comprised of instruction in the topic (i.e., did not contain any SAFMEDS elements such as corrective feedback, fluency aims, timed trials or students recording their own data). At the beginning of each SAFMEDS session, students shuffled their packs. Students were then timed for 1 min by the first author or teacher as they worked through the cards. Students were asked to read the question silently and speak the answer, followed by turning the card over to read the answer. If the student had answered correctly, they placed

the card into one pile (‘correct’ pile) and if they had answered incorrectly, they placed the card into another pile (‘not yet’ pile). After the 1-min timing, students counted the number of cards in each pile and completed their table. In pairs, students were given 2 min to review the cards in their ‘not yet’ pile. Each SAFMEDS session was comprised of four timings, after which students selected their best score for the day to enter into their chart.

Fluency aims were given at the start of each week to students in the intervention group. The aims were based on the results of the previous week. The overall fluency aim was a frequency of > 40 cards correct and < 2 incorrect per min.

Post-tests. Post-tests were conducted at the end of the 4 weeks of intervention during which all students were given quizzes identical to the pre-test and application quizzes under the same instructions and conditions.

Follow-up tests. Four weeks after the post-tests, we gave students follow-up tests identical to the pre- and post-tests.

Results

We used a repeated-measure ANOVA to analyse the changes in the mean scores over the three time points and across the two conditions (SAFMEDS and TAU). To assess the changes, we used the Reliable Change Index (RCI) (Jacobson & Truax, 1991) to determine whether there was a statistically significant difference in an individual student’s improvement scores. We calculated RCI by dividing the change in the student’s score by the standard error of the difference for the test. If the improvement was greater than the RCI, this was considered an educationally-significant gain (e.g., Lipsey & Wilson, 1993). Fluency was calculated by dividing the number of cards answered correctly by the time taken to complete the pack (i.e., 1 min or less).

Figure 1 shows mean number of correct quiz answers during the pre-, post-, and one-month follow-up tests for both the intervention and control groups. There was no significant

difference at pre-test between the control and intervention group ($t(33) = -1.881$, $p = .790$). The results show a main effect of time ($F(2, 66) = 105.420$, $p<.001$, $\eta_p^2 = .76$ a significant time x group interaction $F(2, 66) = 4.438$, $p<.001$ $\eta_p^2 = .55$) and a significant main effect of group ($F(1, 33) = 16.552$, $p<.001$, $\eta_p^2 = .33$). The pairwise comparisons show significant main effect at time between pre- and post-test ($p<.001$), and pre- and follow-up-test ($p<.001$), but no significant difference between post- and follow-up-test ($p=.119$).

Figure 2 shows the improvement scores for the experimental and control group. Improvement scores were calculated by subtracting the post-test from the pre-test score for each student. Scores below zero indicated a decrease in test scores, scores at zero indicated no change in performance, and scores above zero indicated an improvement in the maths test. All students in the experimental group showed an increase in scores from pre- to post-test, and showed an educationally significant gain as determined by the RCI. Only half of the students in the control group showed an increase in performance from pre- to post-test, and only five students in this group met the RCI.

Fluency. Figure 3 shows the pre-, post-, and 1-month follow-up mean test scores for both the intervention and control group. There was no significant difference at pre-test ($t(33) = .178$ $p = .11$) between the control and intervention group. The results of an ANOVA showed a main effect of time ($F(2, 66) = 42.601$, $p<.001$, $\eta_p^2 = .56$ a significant time x group interaction $F(2, 66) = 17.291$, $p<.001$, $\eta_p^2 = .34$), and a significant main effect of group ($F(2, 33) = 9.713$, $p = .004$, $\eta_p^2 = .23$). The pairwise comparisons for the intervention group indicated a significant main effect of time between pre- and post-test ($p<.001$), and pre- and follow-up ($p<.001$), showing that the students became more fluent. There was no significant difference between performance on post- and follow-up tests ($p=.077$).

Application tests. Figure 4 shows the pre-, post-, and follow-up mean application test scores for both the intervention and control group. There was a main effect of time ($F(2, 66) = 22.559$, $p<.001$, $\eta_p^2 = .41$) and a significant interaction $F(2, 66) = 5.754$, $p = .005$, $\eta_p^2 = .15$) but not a significant main effect of group ($F(1, 33) = .002$, $p = .961$, $\eta_p^2 = .00$). The pairwise comparisons showed a significant main effect of time between pre- and post-tests ($p = .001$), pre- and follow-up-tests ($p<.001$), and post- and follow-up-tests ($p = .006$).

Figure 5 shows the pre-, post-, and follow-up mean application test scores for both groups. There was a main effect of time but not a significant interaction or a significant main effect of group ($F(2, 66) = 18.653$, $p<.001$, $\eta_p^2 = .36$; $F(2, 66) = .075$, $p = .075$, $\eta_p^2 = .08$; $F(1, 33) = .136$, $p = .715$, $\eta_p^2 = .00$). Pairwise comparisons indicated a significant main effect at time between pre- and post-tests ($p<.001$), pre- and follow-up-tests ($p<.001$), and post- and follow-up-tests ($p = .010$).

Discussion

We found clear gains for students who had the addition of SAFMEDS to their usual maths instruction through a significant increase in the number of correct quiz questions pre- to post-test. We also found evidence for one of the critical learning outcomes (application) in the results of the application tests; although both groups showed an increase in application test scores pre- to post-test, the SAFMEDS group showed significantly higher gains in the number of correct responses. Our results also provide further support in the use of PT to attain another critical learning outcome (maintenance) because students in the SAFMEDS group maintained the information they had learned after one month of no SAFMEDS instruction. Our study provides the basis of the potential impact of SAFMEDS on students' basic maths skills. Compared to previous research assessing the effectiveness of SAFMEDS,

we have been the first to implement SAFMEDS to increase basic maths skills on a class-wide basis with a mainstream high school population.

In addition to demonstrating application and maintenance, we suggest that we may have addressed a third critical learning outcome; stability. Many PT interventions using SAFMEDS have been done on a one-to-one or small group basis in a quiet, non-distracting environment (e.g., Chapman, Ewing, & Mozzoni, 2005; Chiesa & Robertson, 2000; Hughes, Beverley, & Whitehead, 2007). The students in our study used SAFMEDS in a class-wide environment, which was noisy and potentially distracting. However, we argue that it is important to explore the effectiveness of interventions in real-life settings, under circumstances that might be unavoidable (i.e., it may not be feasible due to time and resources to conduct SAFMEDS in small groups or individually). A risk of conducting research embedded in classroom instruction is extraneous variables. There was a practical limitation in our study in that the control group recapped their lesson on the topic prior to the 1-month follow-up test, whereas the SAFMEDS group had no continued learning on the topic after the four-week intervention. The extra instruction on the topic could account for the increase from the post-test to the 1-month follow-up test for the control group. Although this is a confound, it may suggest that practice is important for retention. Apart from this additional instruction, both groups were exposed to the same amount of learning time for the topic (regardless of whether or not they used SAFMEDS).

Our study shows the benefit and importance of measuring not only accuracy, but also fluency. We found that the inclusion of a time element can aid students' learning and increase fluency. This supports Binder's (1996) claim that a time element can promote mastery of basic maths skills. Although we used a variety of measures in our study, there are others we could have used. In addition to evaluating the effectiveness of an intervention, it is important to measure the social validity of an intervention (Wolf, 1978). Although we did

not measure social validity formally, when we asked the students in the intervention group if they would like to continue using SAFMEDS, approximately 90% of the class raised their hands. In future research, a social validity measure could be used to provide evidence on the acceptability of SAFMEDS to aid learning basic maths skills.

The results of this study are promising, however we acknowledge that our sample size was relatively small when compared to studies exploring other maths intervention programmes such as PALS, Numeracy Recovery Scheme and Catch up Numeracy (e.g., Dowker, 2010; Fuchs, Fuchs, Yazdian, & Powell, 2002). Therefore, further research is needed to assess if the results found in our study can be replicated with a larger sample. Although 1-month follow-up tests were completed, further follows-ups are needed to assess that the information was truly retained in the students' repertoires. As we only focused on a selection of the maths curriculum over a short period, the SAFMEDS were unlikely to have an impact on the school's standardised assessment (i.e., macro level test). Future research could extend across the entire maths curriculum in both primary and high school to assess whether this has an impact on global maths ability as measured in the standardised national tests. We used non-standardised assessments because we wanted the assessments to be as similar to the format of assessments that students experience in their schooling. Future studies could incorporate standardised maths tests, such as TEMA-3 (Ginsburg & Baroody, 2003), TOMA-3 (Brown, Cronin, & Bryant, 2012) or MFaCTs (Reynold, Voress, & Kamphaus, 2015) as the assessments tool to provide further support into the effectiveness of the use of SAFMEDS. An interesting aspect of this study was that the students learnt the information via the SEE-SAY learning channel (student sees the question and says the answer) and were able to transfer the skills to SEE-WRITE (students sees the question and has to write the answer).

In conclusion, our findings provide further evidence to support the use of SAFMEDS in addition to providing new evidence on the utility of SAFMEDS implemented class-wide in a mainstream high school to target basic maths skills.

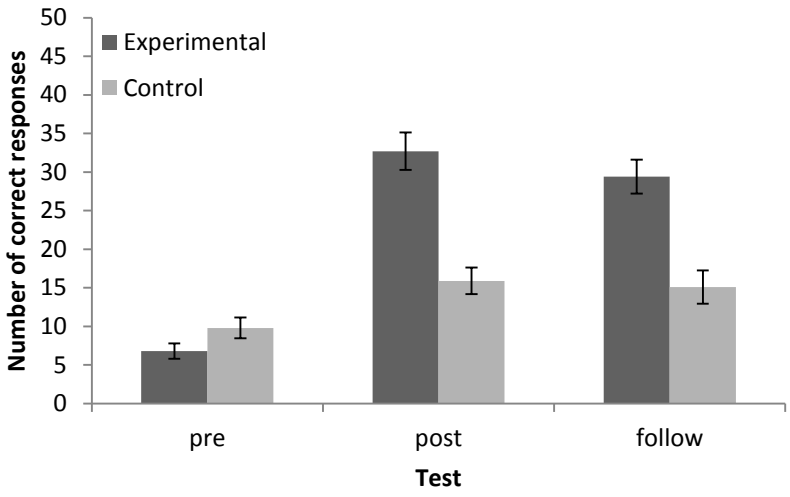

Figure 1. Mean pre-, post-, and 1-month follow-up tests for both the control and intervention group.

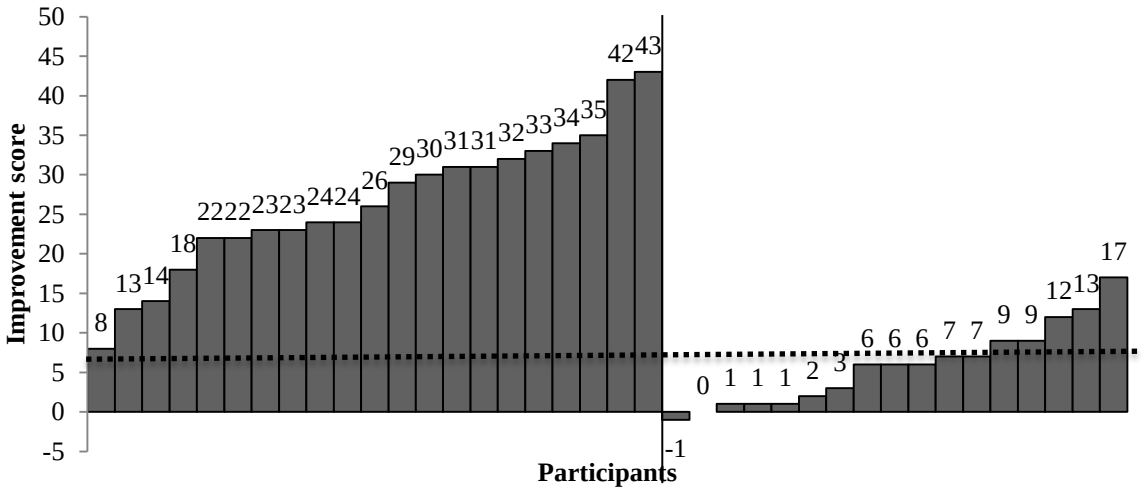

Figure 2. The improvement score from pre- to post-test for each individual student (RCI was 7.49.)

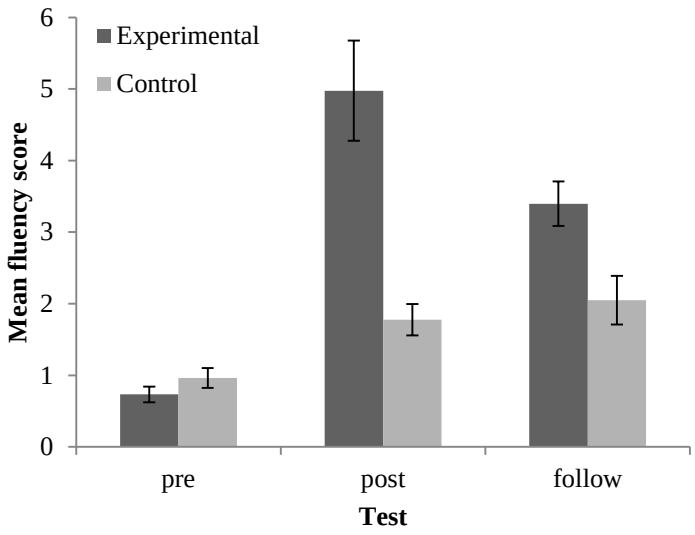

Figure 3. Mean fluency pre-, post, and 1-month follow up-tests for both the control and intervention group.

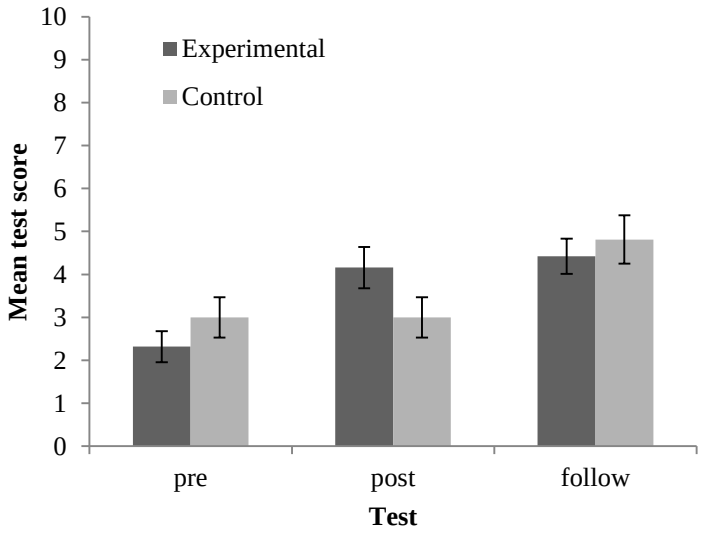

Figure 4. Mean application pre-, post-, and 1-month follow up-tests for both the control and intervention group.

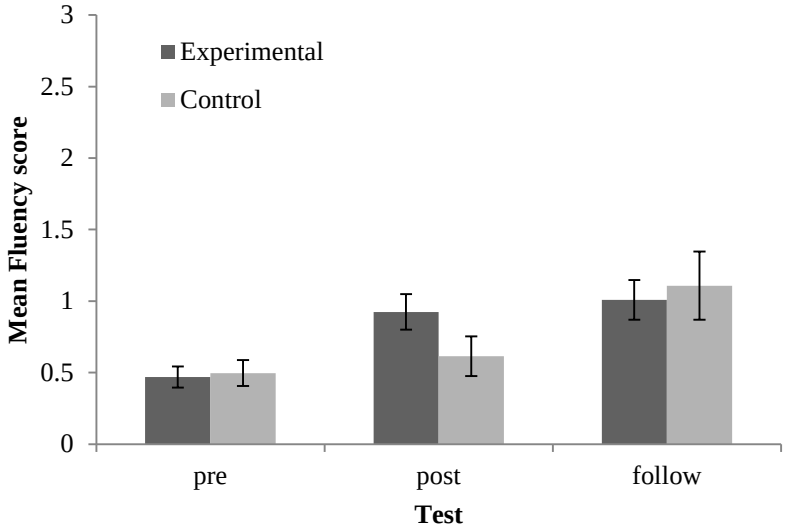

Figure 5. Mean fluency application pre-, post-, and 1-month follow up-tests for both the control and intervention group.

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