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Stacking the Deck in the Learner's Favor: Behavioral Skills Training Improves SAFMEDS Implementation

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Stacking the Deck in the Learners Favor: Behavioral Skills Training Improves SAFMEDS Implementation

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Graduate Faculty
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Abstract

"Say All Fast Minute Every Day Shuffled" (SAFMEDS) is a structured, evidence-based protocol for using flashcards. The protocol is a sequence of steps that are designed to promote accurate and quick responding to learn the information presented on flashcards. Although the benefits of using SAFMEDS have been well-documented, much of the literature fails to adequately describe the methods used to train participants on how to use the protocol. In addition, few studies measure participant procedural integrity (i.e., the extent to which the protocol is implemented as planned). To date, no study has systematically examined the effects of different training methods on the procedural integrity of SAFMEDS implementation. To address this, a multiple baseline design was used to compare the effects of two training methods (i.e., instructions and behavioral skills training) on the percentage of steps completed correctly by 10 undergraduate students. Although instructions alone resulted in slight increases in percent correct, behavioral skills training was needed for the majority of participants to implement the protocol with near-perfect accuracy. During post-training and maintenance, percent correct remained high. Instructions have been the primary method of training students to use SAFMEDS; however, instructions alone are not sufficient. Behavioral skills training is a quick and effective alternative to teach the SAFMEDS protocol with high procedural integrity.

Acknowledgements

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Lauren Olsen

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As high school students transition to college, a large part of their education is dependent on their academic behaviors outside of the classroom. College students are likely expected to spend more time studying as they spend less time in weekly class meetings than they did in high school. Some universities recommend that college students spend at least 2 hr per week studying and completing assignments outside of class for every credit hour in which they are enrolled (e.g., Academic Success Center, 2014; Humboldt State University Learning Center, 2020; Idaho State University, 2023; Jacksonville State University, 2023). Prior research has shown positive correlations between study behaviors and performance in post-secondary education (Beattie et al., 2019; Credé & Kuncel, 2008; Hartwig & Dunlosky, 2012; Masui et al., 2014; Proctor et al., 2006; Vaughn et al., 2021). Given this, training students to effectively use study tools may lead to improved student performance.

One study tool that undergraduate students often report using is flashcards (Golding et al., 2012; Hartwig & Dunlosky, 2012; Karpicke et al., 2009; Kornell & Bjork, 2008; Wissman et al., 2012). Individual use of flashcards varies across aspects such as how many cards are studied at once, how often cards are studied, and criteria for correct responses (Wissman et al., 2012). Despite individual differences, one commonality is that focus is placed on the number of correct or accurate responses (i.e., recalling information on one side of a card from memory). Once an accurate response is

made, students often remove that card from the flashcard deck and stop studying it (Wissman et al., 2012). Measuring accuracy as a learning outcome is not an uncommon practice; quantitative educational assessments (e.g., multiple-choice tests) often determine learning outcomes based on accuracy alone (Cross & Angelo, 1988). However, this may not provide a complete picture of an individual's ability. For example, if two students answered the same number of questions correctly but one finished the exercise in 30 min and the other finished in 5 min, it would be misleading to say they have the same skill level (Hughes et al., 2007).

An alternative to measuring accuracy is measuring fluency, the speed at which accurate responses are made (Binder, 1996). When fluency is assessed repeatedly across time, the resulting measure is celeration, which is typically displayed on a standard celeration chart (SCC). An SCC displays proportional changes in performance (as opposed to line graphs that show absolute changes) using a semi-logarithmic graph. The graphs are standardized (i.e., axes are the same) making visual interpretation of changes in and comparison of performance easier for educators (Calkin, 2005). Visual analysis of an SCC can be used to make individualized, data-based decisions regarding learner performance (e.g., effectiveness of a teaching style, skill mastery, additional training needs).

An evidenced-based flashcard technique that focuses on increasing fluency by monitoring celeration is "Say All Fast Minute Every Day Shuffled" (SAFMEDS). This technique involves following a detailed set of steps (Graf & Auman, 2005; see Table 1). The learner starts by shuffling the cards so that the order is unpredictable. This ensures that responding is under control of the desired stimulus (i.e., the term on the front of the

card) and not the order in which the cards are presented. After shuffling, the learner starts a timer (typically 1 min) so that fluency of responding (opposed to accuracy alone) can be measured. During the timing, the learner looks at the front of the card, audibly states the information on the back of the card (or says skip), and flips the card to check their response. Saying the answer out loud prior to flipping the card ensures that the learner can recall the exact answer from the information on the front of the card alone. Cards are sorted into correct or incorrect piles so that responses can be counted and recorded after the timing is complete. Learners are encouraged to review as many cards as they can during the timing; the fast pace ensures they are not spending too much time reviewing the front of the card. Often, the learner graphs performance on an SCC, and they or their instructor look for changes in the celeration of correct and incorrect responses. The aforementioned steps are repeated daily, which often leads to gains in fluency.

Table 1

Steps of the SAFMEDS Protocol

Step	Details
1	Shuffle the flashcards
2	Start a 1-min timer
3	Briefly look at the front of the card
4	Say the answer or say "skip"
5	Check your response
6	Sort the card into the correct or incorrect pile
7	Repeat steps 3-6 as quickly as possible until timer ends
8	Count the number of correct and incorrect responses
9	Record results on a Standard Celeration Chart
10	Complete this process daily

Note. There are multiple variations and supplemental procedures of the "Say All Fast Minute Every Day Shuffled" (SAFMEDS) protocol.

Since the 1980's, the SAFMEDS protocol has been recommended to educators to enhance student learning (e.g., Eaton & Fox, 1983; Eshleman, 1985; Lindsley, 1996). SAFMEDS has now been used to teach a variety of populations across multiple subject areas. Approximately 47% of the peer-reviewed studies evaluating SAFMEDS have included undergraduate or graduate student participants (for review, see Quigley et al., 2018). This population's use of SAFMEDS has led to increased fluency in areas such as learning a second language (Togade et al., 2012), vocabulary terms (Urbina et al., 2021), and electrocardiogram interpretation (Rabbitt et al., 2020). In addition to helping students initially learn material, some studies have shown that SAFMEDS can lead to endurance during long testing periods (Kim et al., 2001), retention of performance over time

(Kubina et al., 2016), and the application of performance standards to different assessments (Polson et al., 1997).

Though the effectiveness of SAFMEDS has been well documented, prior research has been criticized for containing inconsistencies in how the procedure is used. For instance, some studies include multiple daily timings, vary the timing length, or employ error correction techniques (for review, see Quigley et al., 2018). Although deviations from the basic SAFMEDS protocol are not necessarily problematic, few studies have systematically examined the effects of procedural variations. Perhaps most concerning is that some studies fail to clearly describe the methodology used (e.g., McDade & Olander, 1990; Polson et al., 1997). Given this, it is difficult to know what SAFMEDS variant(s) produces the best outcomes for the majority of learners.

In addition to systematically evaluating parametric/procedural manipulations and adequately defining the methodology, the procedural integrity (i.e., the extent to which a protocol is implemented as intended) of SAFMEDS should also be evaluated. When used with adult populations, SAFMEDS is typically implemented by the learner making procedural integrity largely dependent on the behavior of the learner. Quigley et al. (2018) conducted a review of the SAFMEDS literature that included 27 peer-reviewed empirical articles; of those studies, 15 used adult participants that primarily self-administered SAFMEDS. Since 2013, 12 additional peer-reviewed, empirical studies have been published using adult participants who self-administered SAFMEDS[1]. Of the

[1] Quigley et al. (2018) reviewed the SAFMEDS literature through December 2013. A partial replication of the review was conducted for the current study to identify relevant studies published from January 2014 to February 2023. A similar keyword ("SAFMEDS") and database (Google Scholar) were used to identify articles published since the 2018 review.

combined 27 articles[2], only two reported data on participant procedural integrity. Kubina et al. (2016) included some measures of participant behavior (e.g., correct number of trials completed, number of sessions per week), but did not measure all aspects of completing the protocol. Quigley et al. (2021) collected data on the percent of SAFMEDS steps correctly implemented by participants. Without measures of participant implementation, it is difficult to know what aspects of the protocol are being used with integrity. One potential way to increase the likelihood that SAFMEDS has been implemented correctly is to provide sufficient training and monitor procedural integrity throughout the course of the research.

Unfortunately, the training method given to participants on how to use the SAFMEDS protocol is often unstated or unclear. In the aforementioned studies using adult participants that self-administered SAFMEDS, 15 provided no indication that participants were given any type of training or instruction (Adams et al., 2018; Bower & Orgel, 1981; Calkin, 1996; Cobane & Keenan, 2002; Eaton & Fox, 1983; Eshleman, 1985; Kim et al., 2001; Kubina et al., 2016; McDade et al., 1985; McDade & Olander, 1990; Olander et al., 1986; Schulz & Francisco, 2020; Stockwell & Eshleman, 2010; Togade et al., 2012; Urbina et al., 2021). Beverley et al. (2009) and McGrath et al. (2018) stated that a training session was provided but did not describe the instructional methods used. Some studies reported giving instructions to complete up to two steps in the procedure such as respond audibly (Korinek & Wolking, 1984; Mason et al., 2018) or respond quickly (Commons et al., 2014; Polson et al., 1997); however, it is unlikely that

[2] The 27 articles (see Appendix A) include those reviewed by Quigley et al. (2018) and those found in the search described above.

one or two instructions were sufficient to complete the entire SAFMEDS protocol correctly. In five cases, descriptions of all steps of SAFMEDS were provided using written (Dunne et al., 2022), verbal (Lydon et al., 2021; Meindl et al., 2013; Rabbitt et al., 2020), or both types of instructions (Branch et al., 2018). In addition to instructions, Lydon et al. (2021) and Rabbit et al. (2020) provided a "tutorial" on how to use SAFMEDS but did not describe what the tutorial entailed. Adequately describing and evaluating the training method needed to accurately implement SAFMEDS could inform future research and educational practices.

From the combined 27 articles, one included a detailed description of the use of behavioral skills training (BST) to teach SAFMEDS (Quigley et al., 2021). BST is a method for teaching performance-based skills quickly and accurately (for review, see Kirkpatrick et al., 2019). BST involves written and verbal instructions, models of the skill, and rehearsal opportunities coupled with feedback. Rehearsal opportunities (and sometimes additional models) are repeated until the trainee performs the skill to the set mastery criteria, which ensures that all essential steps are implemented correctly. Chirinos (2018) and Quigley et al. (2021) described a study in which participants received vocal instructions and viewed a video model and a live model of the procedure. This was followed by practice opportunities and feedback after each flashcard timing. Training continued until the SAFMEDS steps were completed with ≥ 80% accuracy and at least 20 cards were reviewed in 1 min, which took four or fewer timings for each participant.

Given that SAFMEDS is a structured technique with specific steps, BST may increase the integrity with which learners implement the procedure compared to training

with instructions alone. To date, there has been no direct comparison of the training method needed to accurately implement the SAFMEDS protocol. Thus, the purpose of the present study was to determine if instructions alone were sufficient to train individuals to accurately use the SAFMEDS protocol or if a more extensive procedure (i.e., BST) was necessary.

To this end, a multiple baseline across participants design was used to assess pre-training flashcard use and to compare two training methods (i.e., instructions and BST) on the implementation of the SAFMEDS protocol. During pre-training (baseline), participants were instructed to demonstrate their typical use of flashcards. Next, the participants read written instructions on how to implement the SAFMEDS protocol followed by an opportunity to demonstrate the skill. After the instructions-only condition, BST was used to teach the SAFMEDS protocol; this condition continued until participants reached the mastery criteria or after 30 min had passed. A post-training and a maintenance session were conducted to assess participant implementation of SAFMEDS in the absence of proximal training and to evaluate the durability of this skill.

Method

Participants

Eleven participants were recruited for the study; however, one participant did not complete the BST condition and was excluded from the results. The participants were undergraduate students enrolled in a lower-level undergraduate psychology course at a southeastern university. Approval for this study was obtained by the university's institutional review board (see Appendix B for approval letter), and each participant gave written informed consent prior to their inclusion in the study. To participate, students had to be at least 18 years old and have no prior exposure to the SAFMEDS protocol. Participant demographics varied across age, gender, year in college, and grade point average (see Table 2). For session attendance, participants received up to three extra credit points in their course.

Table 2

Participant Demographics

Participant #	Demographics			
	Age	Gender	Year	GPA Range
1	19	Female	Freshman	3.7-4.0
2	18	Female	Freshman	3.7-4.0
3	18	Female	Freshman	2.7-3.1
4	19	Female	Sophomore	3.7-4.0
5	21	Female	Sophomore	2.7-3.1
6	18	Female	Freshman	1.7-2.1
7	20	Female	Junior	3.2-3.6
8	19	Female	Sophomore	3.2-3.6
9	19	Male	Freshman	3.2-3.6
10	26	Female	Junior	3.2-3.6

Note. GPA, grade point average

Setting and Materials

Sessions took place in an 11 ft by 10 ft, 8 in (3.4 m by 3.3 m) room containing two tables and three chairs. The participants sat at a small table across from the primary observer. When they were not in use, materials for the study (described below) were kept on a larger table on the left side of the room. To ensure accurate data collection and assess interobserver agreement (IOA) and procedural integrity, both the observer and the participant were video recorded using an Apple iPad (iPad mini 3), which was placed behind the participant in the right corner of the room.

Materials used in this study included a deck of flashcards, a timer, a score sheet to record the number of correct and incorrect responses, an SCC, and a pre- and post-training questionnaire (see Appendices C and D, respectively). The flashcard deck

included 40 laminated cards measuring 3 in. x 5 in. (76.2 mm x 127 mm). A picture and a term were printed on the front and back of each card, respectively. All pictures were obtained from Google Images using the "Creative Commons Licenses" filter. The deck contained cards that were likely to evoke correct, incorrect, and skip responses (Quigley et al., 2021); for examples of each category, see Appendix E. Cards likely to evoke correct responses contained a common picture with a common term (e.g., a picture of crayons with the term "crayons"). Cards likely to evoke incorrect responses contained a common picture with an uncommon term (e.g., a picture of a cat with the term "feline"). Cards likely to evoke skip responses included an uncommon picture with an uncommon term (e.g., a picture of a dodecahedron with the term "dodecahedron"). Cards selected for each category were evaluated for the desired response by four undergraduate students that did not participate in the current study.

Data Collection

The primary observer was a graduate student at the university with a Bachelor of Science Degree in Psychology. All procedures and within-session data collection were completed by the primary observer. Before collecting data, the primary observer was trained to an average of ≥ 90% IOA and procedural integrity across two consecutive practice sessions.

Data collection lasted 11 weeks (January 23rd through April 10th, 2023). Across all conditions, participants completed at least one trial. The dependent variable was the percent of SAFMEDS steps completed correctly. Within each session, participant performance was evaluated by scoring each step of SAFMEDS as correct (1 point) or

incorrect (0 points) and indicating why steps were missed. If it was ambiguous whether a step should be scored as correct or incorrect (e.g., a participant spoke so quickly that it was unclear if they said a term before checking their response), the primary observer reviewed videos to ensure scoring was as accurate as possible. Each step was given criteria for what defined a correct or incorrect response (see Appendix F). Percent correct was calculated by dividing the number of steps completed correctly by the total number of steps (11) and multiplying by 100.

Interobserver Agreement and Procedural Integrity

A secondary observer collected data using the session recordings to assess IOA and the procedural integrity of the primary observer. Trial-by-trial IOA was calculated for 33% of sessions from each condition by dividing the number of agreements by the total number of opportunities for agreement (11) and multiplying by 100. Overall IOA was an average of 99% (range = 97–100%).

Procedural integrity data were collected for 33% of sessions from each condition by dividing the number of steps completed correctly by the total number of steps and multiplying by 100. The steps for collecting data on procedural integrity varied for each condition (see Appendix G). Overall procedural integrity was an average of 98% (range = 92–100%).

Procedures

A multiple baseline across participants design was used in the current study. Every four participants were pseudo randomly assigned to receive one or two pre-training sessions with the constraint that an equal number of participants be assigned to each tier. The experiment consisted of five conditions: pre-training, instructions only, BST, post-

training, and maintenance. Each condition consisted of one or more trials in which participants completed a 1-min timing with flashcards and had opportunities to complete pre- and post-timing activities (i.e., shuffling cards, writing number of correct and incorrect responses, and graphing their results). They had access to a pencil, a timer, a deck of flashcards, a score sheet, and an SCC throughout each trial.

Pre-Training

A pre-training condition was conducted to evaluate baseline flashcard use. In the first session, participants completed a questionnaire regarding demographics, familiarity with SAFMEDS, and flashcard use (Appendix C). Next, they were instructed to use the materials provided to demonstrate how they would typically use flashcards to study (i.e., complete a trial). A trial began when a participant started using any of the materials provided. After 1 min, participants were asked to describe any other methods or materials they would normally use to study flashcards. During this condition, participants were not given access to instructions or information about SAFMEDS.

Participants completed one to three pre-training sessions. If participants showed an increase by two or more steps, then an additional trial was conducted during the last pre-training session. Each pre-training session lasted an average of 5 min (range = 3–7 min), and the last pre-training session occurred on the same day as the first instructions-only session.

Instructions Only

To evaluate the effects of written instructions on SAFMEDS implementation, participants read aloud instructions on how to use the SAFMEDS protocol followed by an opportunity to review the instructions silently for up to 3 min. Throughout the session,

participants had access to the materials and the written instructions, which included a list of steps (see Table 3); for details corresponding to each step, see Appendix H.

Table 3

Written Instructions Steps

Order	Step
1	Shuffle the cards
2	Start the 1-min timer
3	Pick up a card from the top of the stack
4	Look at the picture on the front of the card
5	Say the name of the picture or say “skip”
6	Flip the card over to check your response
7	Sort the card into correct or incorrect pile in front of you
	Repeat steps 3-7 with the next card
8	Continue as quickly as you can before the timer stops
9	Stop immediately after the timer beeps
10	Count how many correct and incorrect responses you have
11	Graph your results by following the steps below
11a	Find the date
11b	Indicate how long your timing lasted
11c	Record the number correct with a closed circle
11d	Record the number of incorrect with an X

Note. See Appendix H for full written instructions.

After participants finished reviewing the instructions or after 3 min elapsed, they were instructed to implement the protocol (i.e., complete a trial). A trial began when a participant started any of the steps in the written instructions and ended when the participant finished graphing their data, skipped the graphing step, or after they spent 5 min on graphing (Step 11). The primary observer recorded data on the dependent measure but did not provide any performance feedback. If a participant failed to start the

1-min timer (Step 2), the primary observer indicated when 1 min had passed and instructed the participant to continue completing the steps. If a participant asked a question about the protocol at any point, they were told to follow the instructions as they understood them.

Participants completed two to three instructions-only sessions, each lasting an average of 12 min (range = 7–19 min). During the final instructions-only session, an additional trial(s) was conducted if percent correct increased from the preceding trial.[3] The last instructions-only session occurred on the same day as the first BST session.

Behavioral Skills Training

BST was provided to compare the effects of this training method to the effects of instructions on SAFMEDS implementation. BST included written and vocal instructions, modeling, rehearsal, and feedback. The written instructions were the same as those used during the instructions-only condition. Throughout this condition, the written instructions and all other materials were located on the table in front of participants. At the beginning of the session, the primary observer provided the participant with a visual aid that contained the acronym "SAFMEDS" and corresponding words for each letter. The rationale and steps of the SAFMEDS protocol were verbally described using a script (see Appendix I).

After providing verbal instructions, the primary observer modeled all steps of the SAFMEDS protocol. This also served as an opportunity to identify specific steps that participants missed during the instructions-only condition (Participants 1, 3, and 6 did not

[3] Due to a researcher error, Participant 5 was pre-maturely advanced to the BST condition and did not receive an additional trial during the instructions-only condition.

have errors addressed during the model). Next, participants were given the opportunity to ask questions and rehearse the SAFMEDS protocol (i.e., complete trials). Each trial began when the participant started any step of the SAFMEDS protocol and ended when the participant indicated they were finished graphing. During each trial, the primary observer collected data on correct and incorrect completion of SAFMEDS steps and, following the trial, used this data to provide verbal feedback to participants. For each step performed correctly, the primary observer provided a brief behavior-specific praise statement (e.g., "You did a great job shuffling the cards so that the order was unpredictable!"). For each step performed incorrectly, the primary observer identified the error, how to address the error, and the rationale for completing the step correctly (e.g., "You did not check your responses for cards that you skipped. Next time, make sure you flip the card over so you can see the correct response. This will help you learn the correct response over time."). In some instances, the primary observer used the materials when providing feedback. For example, if a participant graphed a data point incorrectly, the primary observer used the SCC to identify the error and modeled a correct graphing response.

Rehearsal opportunities and feedback were repeated until the participant reached mastery criteria (³ 90% steps correct across three consecutive trials) or after 30 min had passed. Participants completed one BST session that lasted an average of 25 min (range = 18–29 min) and consisted of an average of four trials (range = 3–5).

Post-Training

Approximately 1 week (range = 7–8 days) following BST, participants completed a post-training session during which their ability to implement the SAFMEDS protocol

without any proximal training was assessed. Participants were not provided with instructions, and the primary observer did not answer any questions or discuss the SAFMEDS protocol. Participants completed one trial using the SAFMEDS protocol followed by a post-training questionnaire regarding the social validity of the procedures used in the current study and the SAFMEDS protocol (Appendix D). Participants completed one post-training session lasting an average of 5 min (range = 4–6 min).

Maintenance

Approximately 5 weeks (range = 4–7 weeks) after the post-training session, participants completed one maintenance session to assess performance durability. The procedures for the maintenance session were the same as in post-training with the exception that participants did not complete the post-training questionnaire; after completing one trial, they were asked to discuss their use of the SAFMEDS protocol or any other flashcard technique since participating in this study. Maintenance sessions lasted an average of 5 min (range = 4–7 min).

Results

The results from the relevant pre-training questionnaire items are displayed in Table 4.[4] Flashcards were marked as a useful study tool by nine of the participants; however, the majority reported that they rarely or never used flashcards. Five participants noted that no instructor had recommended flashcard use in the previous semester. The other five reported that one instructor had recommended flashcard use, but only one of these participants reported that their instructor gave them instructions on how to use flashcards. In response to open-ended questions, all participants reported sorting flashcards; however, there were variations in reported use of error correction, amount of the deck studied at once, and whether the cards are shuffled.

Table 4

Pre-Training Questionnaire Results

Item #	Questions	Item Choices	Percent (%)
5	Do you think that flashcards are a useful study tool?	Yes	90
		No	10
6	How often do you use flashcards as a study tool?	Very Frequently	0
		Frequently	20
		Sometimes	20
		Rarely	40
		Never	20
7	In the past semester, how many college instructors have recommended flashcards as a study tool in their class?	0	50
		1	50
8	In the past semester, did any college instructor give instructions on how to use flashcards?	Yes	10
		No	30
		Not Recommended	60

[4] Some questionnaire items served as pilot data for future research and had no direct implications for the current study; however, complete questionnaire responses are presented in Appendix C.

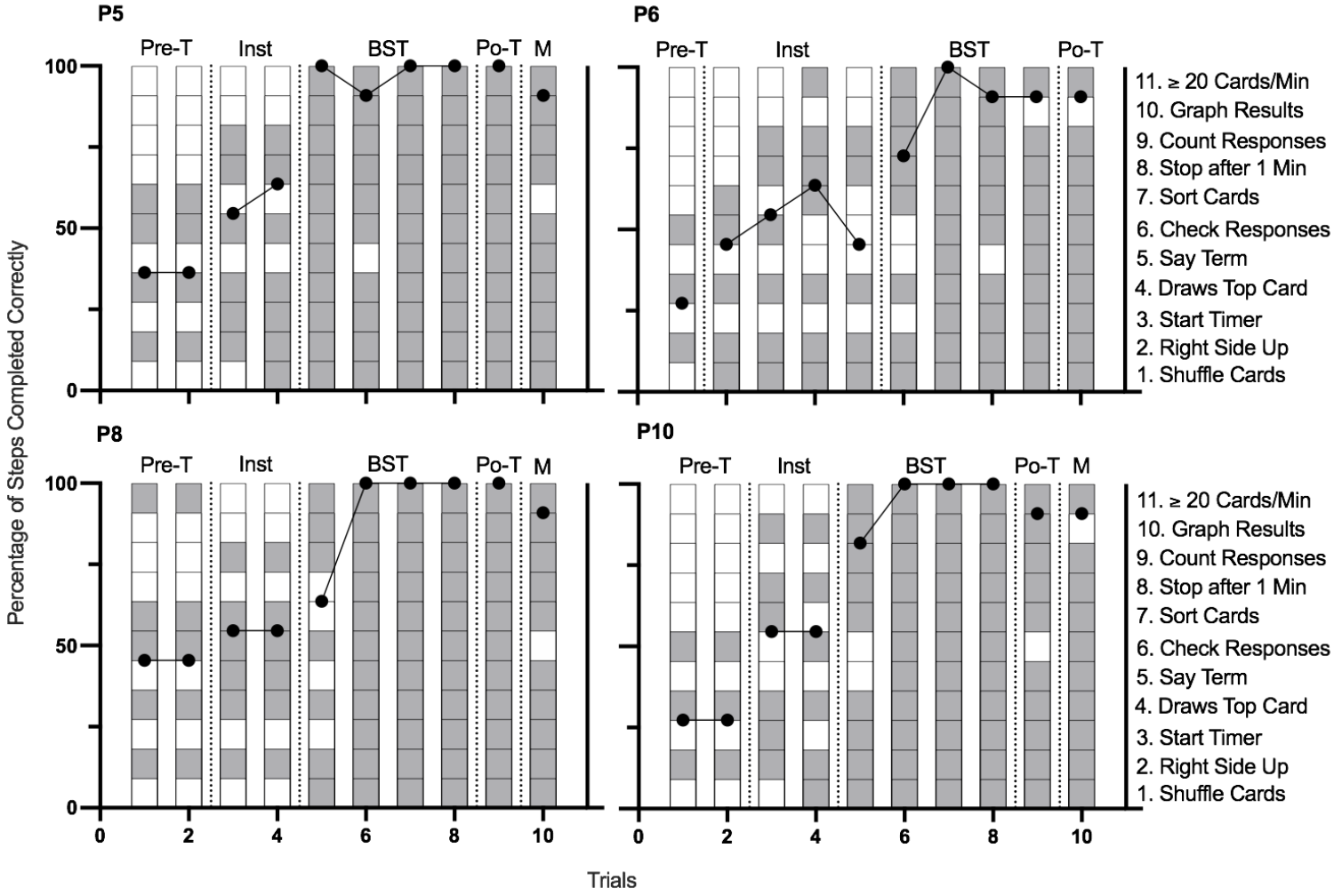
Overview of Trial Performance

Figures 1, 2, and 3 display the percent of SAFMEDS steps implemented correctly (closed squares) and incorrectly (open squares) across all conditions. Throughout pre-training, percent correct was low (*M* = 35%; range = 18–45%). Training with instructions led to an increase in percent correct (*M* = 62%; range = 36–100%). Further increases were observed in the BST condition (*M* = 90%; range = 45–100%). Seven participants met the mastery criteria (i.e., ≥ 90% correct across three consecutive trials; see Figures 1 and 2). Although the remaining three participants did not reach mastery levels, they averaged ≥ 90% correct on their last three trials (see Figure 3). Percent correct remained high during post-training (*M* = 94%; range = 91–100%) and maintenance (*M* = 88%; range = 64–100%).[5]

[5] Only nine participants completed maintenance.

Figure 1

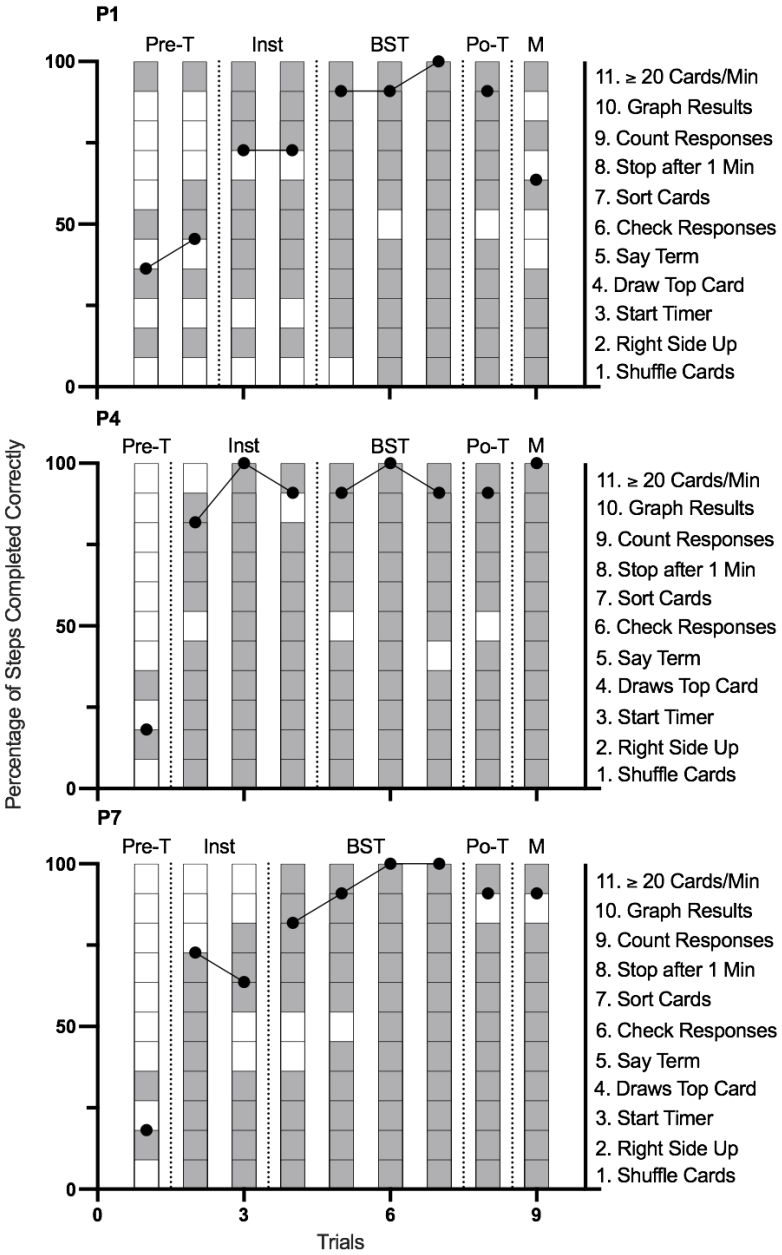
Percent Correct and Individual Step Performance for Participants Meeting Mastery Criteria



Note. Percent correct is depicted on the left y-axis for pre-training (Pre-T), instructions only (Inst), behavioral skills training (BST), post-training (Po-T), and maintenance (M) trials. Gray and white squares correspond to "Say All Fast Minute Every Day Shuffled" (SAFMEDS) steps completed correctly and incorrectly, respectively (right y-axis).

Figure 2

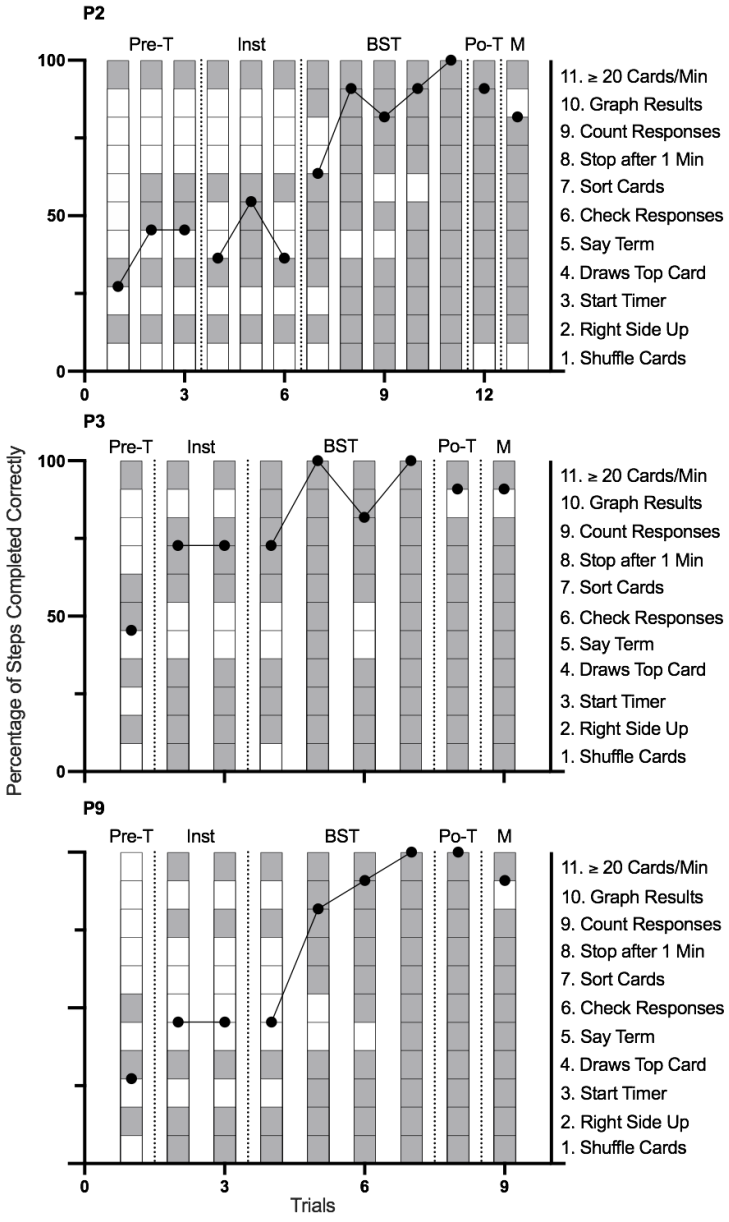
Percent Correct and Individual Step Performance for Additional Participants Meeting Mastery Criteria



Note. Percent correct is depicted on the left y-axis for pre-training (Pre-T), instructions only (Inst), behavioral skills training (BST), post-training (Po-T), and maintenance (M) trials. Gray and white squares correspond to "Say All Fast Minute Every Day Shuffled" (SAFMEDS) steps completed correctly and incorrectly, respectively (right y-axis).

Figure 3

Percent Correct and Individual Step Performance for Participants Not Meeting Mastery Criteria



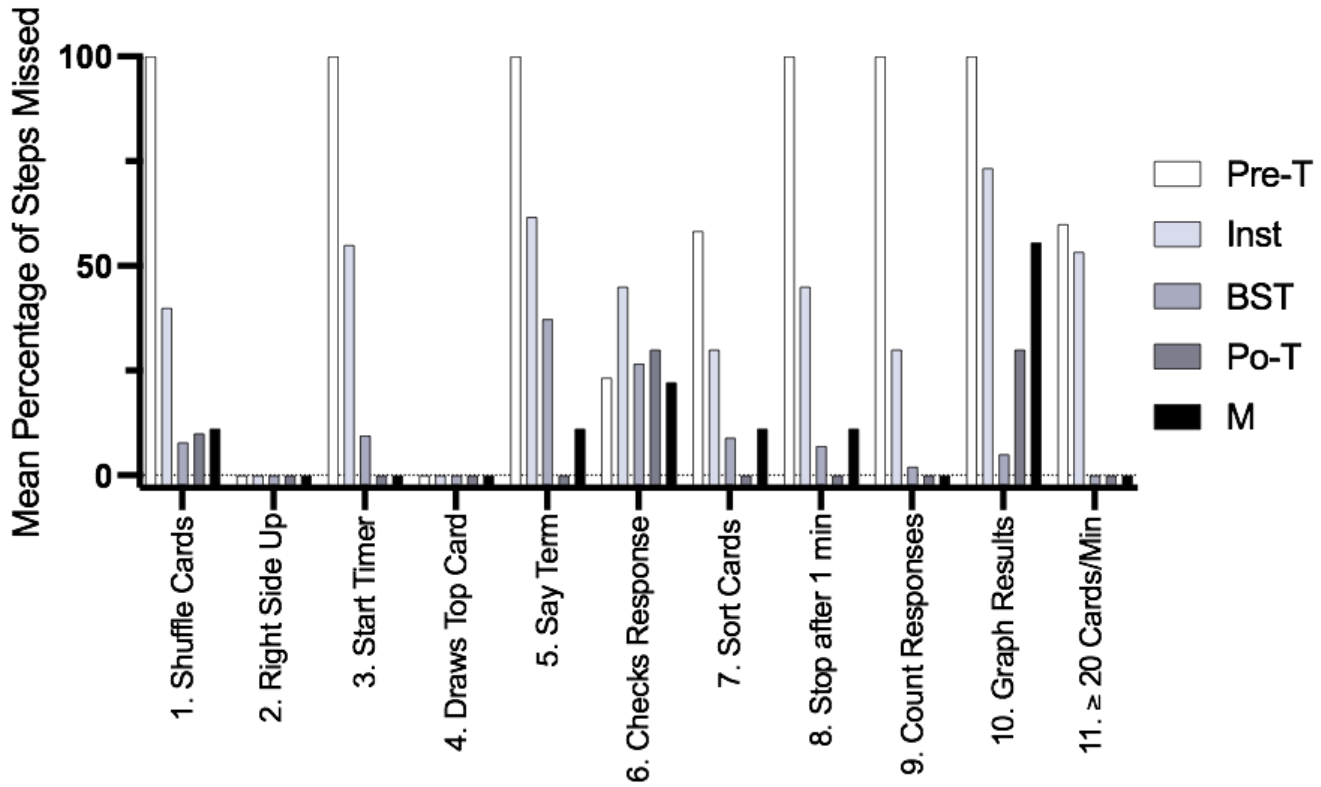
Note. Percent correct is depicted on the left y-axis for pre-training (Pre-T), instructions only (Inst), behavioral skills training (BST), post-training (Po-T), and maintenance (M) trials. Gray and white squares correspond to "Say All Fast Minute Every Day Shuffled" (SAFMEDS) steps completed correctly and incorrectly, respectively (right y-axis).

Steps Implemented Incorrectly

The steps implemented incorrectly during each trial for individual participants are shown in Figures 1, 2, and 3. The mean percent of incorrect steps across conditions is shown in Figure 3. In the pre-training condition, six steps were always missed: shuffling, starting the timer, saying a term or "skip," counting responses, and graphing results (Steps 1, 3, 5, 8, 9, and 10). During the instructions-only condition, participants commonly missed starting the timer, saying a term or "skip," graphing their results, and going through at least 20 cards per min (steps 3, 5, 10, and 11). Throughout the BST condition, saying a term or "skip" and checking response (Steps 5 and 6) were the most frequently missed steps. In post-training, participants commonly missed checking their responses and graphing their results (Steps 6 and 10). By far, the most missed step during maintenance was graphing results (Step 10).

Figure 4

Mean Percentage of Incorrect Steps across Conditions



Note. Pre-training (Pre-T), instructions (Inst), behavioral skills training (BST), post-training (Po-T), and Maintenance (M), "Say All Fast Minute Every Day Shuffled" (SAFMEDS). The dotted line indicates zero steps were missed.

Social Validity

The results from the post-training questionnaire are shown in Table 5. All participants agreed to some degree that SAFMEDS was easy to learn after reading the instructions and that BST was helpful in learning SAFMEDS. When asked if SAFMEDS would be a beneficial method for studying terms, seven participants strongly agreed, two somewhat agreed, and one neither agreed nor disagreed. During post-training, all participants reported that they were likely to use SAFMEDS in the future; however, only one participant indicated using SAFMEDS in the maintenance interim period.

Table 5

Social Validity Questionnaire Results

Item #	Statement	Mean	Range
1	The SAFMEDS protocol was easy to learn after instructions.	4.8	4-5
2	BST was helpful in learning the SAFMEDS protocol.	4.9	4-5
3	I think SAFMEDS would be a beneficial method to study terms.	4.6	3-5
4	How likely are you to use SAFMEDS in a future class?	2.5*	2-3*

Note. The following rating scale was used for items 1-3: Strongly agree = 5; Somewhat agree = 4; Neither agree nor disagree = 3; Somewhat disagree = 2; Strongly disagree = 1. * Indicates different scale used for item 4: Very likely = 3; Somewhat likely = 2; Not likely = 1. “Say All Fast Minute Every Day Shuffled” (SAFMEDS).

Discussion

The current study examined pre-training flashcard practices and evaluated two methods (instructions only and BST) to teach the SAFMEDS protocol. The main findings showed that, although instructions alone resulted in some increases in performance, they were not sufficient to reach the predefined mastery criteria; however, BST resulted in increases to ≥ 90% accuracy for all participants. Percent correct remained high during post-training and maintenance timings.

Overall correct implementation of the SAFMEDS protocol was low during pre-training, as was expected of individuals with no prior history with the protocol. Participant flashcard use and methodological variations are consistent with prior reports (e.g., Wissman et al., 2012). Although percent correct increased from the pre-training to instructions-only condition, only one participant implemented the steps with > 90% accuracy. Thus, it is likely that the majority of learners will need more extensive training to correctly implement SAFMEDS. The importance of rehearsal and feedback as a part of the BST treatment package was evident as most participants needed more than one BST trial to show substantive improvements. Finally, most participants remained at mastery levels during post-training and maintenance (100% and 78% of participants, respectively) supporting prior research on the durability of BST (e.g., Aherne & Beaulieu, 2019; Belisle et al., 2016).

Although BST resulted in large increases in performance for all participants, three did not meet the stringent mastery within the time allotted (30 min). However, the level of performance and increasing trends suggests that, with additional BST trials, the

mastery criteria would have been met. Furthermore, the mastery criteria in this study were more stringent than those with similar training procedures (i.e., ≥ 80% correct across one trial in Chirinos, 2018 and Quigley et al., 2021), and there were strict definitions for performing steps correctly. Steps 4-6 (see Table 1) were scored as incorrect if a participant missed one card (e.g., failing to say "skip" once, omitting one checking response, sorting one card incorrectly) and correctly completed that step with all other cards reviewed. Participants could also miss step 10 (graphing) due to small errors (e.g., graphing the number of correct or incorrect responses more than one point off). Whether these minor mistakes impact the benefits of using SAFMEDS is an empirical question.

Participant approval of BST supports previous research suggesting it is a socially valid training method (for review, see Kirkpatrick et al., 2019). Additionally, high social validity ratings were observed for SAFMEDS. Though this finding is consistent with the results of Kourassanis-Velazques (2019), other studies report low social validity (Adams et al., 2018; Cihon et al., 2012; Urbina et al., 2021). The disparate findings could be due to methodological differences. First, the current study focused on training the implementation of SAFMEDS versus applying the protocol in a class, which resulted in fewer overall trials than past research. Due to the presence of the primary observer, demand characteristics may also contribute to the current results (e.g., participants may have scored items based on what they thought the observer wanted). Although participants reported they were likely to use SAFMEDS in the future, only one said that they used SAFMEDS between post-training and maintenance. However, participants were not instructed to use the protocol outside of the experimental context. Assessing

social validity measures could inform which procedural variations increase student use of SAFMEDS and, in turn, the adoption of SAFMEDS by educators.

One limitation of the current study that is inherent when using a within-subjects design to teach a performance-based skill is practice effects. Participants 1 and 5 showed gains in responding during the pre-training and instructions-only conditions, respectively. However, subsequent trials were not conducted to evaluate if continued gains would have occurred. We allowed for percent correct to increase by one step during pre-training because participants did not use methods similar to SAFMEDS on their first trial making it unlikely that practice alone would result in socially significant increases. During the instructions-only condition, any increase in percent correct was followed by one additional trial to identify the extent to which instructions led to gains in responding. One exception was that Participant 5 was pre-maturely advanced to the BST condition. With additional trials, this participant may have had further increases in percent correct. Despite this oversight, the participant immediately increased from 64% correct in instructions to 100% correct in BST suggesting that BST was more effective. Participant gains after instructions suggest that instructions alone can be used to teach some steps of the SAFMEDS protocol; however, because of the large increases in percent correct when moving from instructions-only to BST, it is unlikely that a practice effect alone can explain the current findings. Nevertheless, future research could vary the length of the instructions-only condition and include stability criteria, which would allow for a more thorough evaluation of practice effects.

A second limitation of the current study is that the procedures may lack generality to the classroom setting. First, it is unlikely that an educator would provide instructions

by repeatedly sitting down with a student and having them read the instructions aloud. This over-training may have contributed to the slight increases in percent correct following the instructions-only condition. Future research could explore a more externally valid implementation of the instructions-only condition. Second, BST was implemented individually with participants, which may be unfeasible for an instructor; additional research is needed to identify the effects of BST to teach SAFMEDS in a group setting (e.g., a classroom).

Certain aspects of the SAFMEDS protocol were not included in the current study and provide additional directions for future research. Graf and Auman (2005) recommend that SAFMEDS be studied daily; however, this aspect was excluded as it did not allow for repeated rehearsal and feedback in one session. In the future, researchers could assess the extent to which this step is implemented correctly and examine procedures such as prompting, self-monitoring, or contrived permanent products (e.g., video recordings of timings) that may help students use SAFMEDS daily. In addition, given that half of the participants in the current study indicated using some type of error correction, it may be beneficial to know the impact of training on the procedural integrity with which evidenced-based error correction techniques are used by students.

No study has systematically examined the training method needed to teach the SAFMEDS protocol. This, coupled with the lack of methodological detail of training preparations in the literature, may decrease the integrity with which SAFMEDS is used in the classroom or reduce adoption of this technique. The current findings showed that BST resulted in near-perfect implementation of the SAFMEDS protocol; instructions alone did not. Thus, BST may be an effective and socially valid method for training undergraduate

students to use SAFMEDS with high procedural integrity in approximately 30 min. As more research is done on the procedural variations of SAFMEDS (e.g., Quigley et al., 2021), researchers should ensure that the only aspect of the SAFMEDS protocol being manipulated is the procedural variation and not participant implementation of the protocol. Procedural integrity data is often neglected in the SAFMEDS (and applied behavior analysis; Essig et al., 2023) literature and is important for ensuring the independent variable is implemented as planned.

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Appendix A

Articles from Literature Review

The following articles were included in Quigley et al. (2018) literature review:

Beverley, M., Hughes, J. C., & Hastings, R. P. (2009). What's the probability of that? Using SAFMEDS to increase undergraduate success with statistical concepts. *European Journal of Behavior Analysis, 10*(2), 183-195. https://do8i.org/10.1080/15021149.2009.11434321

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Kim, C., Carr, J. E., & Templeton, A. (2001). Effects of fluency building on performance over "long" durations and in the presence of a distracting social stimulus. *Journal of Precision Teaching and Celeration, 17*(2), 7-26. https://celeration.org/wp-content/uploads/2020/05/2001_JPTC_V17.02_02.pdf

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Meindl, J. N., Ivy, J. W., Miller, N., Neef, N. A., & Williamson, R. L. (2013). An examination of stimulus control in fluency-based strategies: SAFMEDS and generalization. *Journal of Behavior Education, 22*, 229-252. https://doi.org/10.1007/s10864-013-9172-6

Olander, C. P., Collins, D. L., McArthur, B. L., Watts, R. O., & McDade, C. E. (1986). Retention among college students: A comparison of traditional versus precision teaching. *Journal of Precision Teaching, 6*(4), 80-82. http://celeration.org/wp-content/uploads/2017/02/JPTC_V06.04_02.pdf

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Stockwell, F., & Eshleman, J. (2010). A case study using SAFMEDS to promote fluency with Skinner's verbal behavior terms. *Journal of Precision Teaching and Celeration, 26*, 33-40. https://files.eric.ed.gov/fulltext/EJ968468.pdf

Togade, D., Ormandy, S., & Stockwell, F. (2012). Fluency: Skill acquisition of common tagalog words and symbols. *Journal of Precision Teaching and Celeration, 28*, 17-21.

The following articles were identified from a partial replication of that review:

Adams, O., Cihon, T., Urbina, T., & Goodhue, R. (2018). The comparative effects of cumulative and unitary SAFMEDS terms in an introductory undergraduate behavior analysis course. *European Journal of Behavior Analysis, 19*(2), 176-194. https://doi.org/10.1080/15021149.2017.1404394

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Appendix B
Approval Letter

Institutional Review Board for the Protection of Human Subjects in Research
249 Angle Hall
700 Pelham Road North
Jacksonville, AL 36265-1602

December 8, 2022

Lauren Olsen
Jacksonville State University
Jacksonville, AL 36265

Dear Lauren:

Your protocol for the project titled "An Evaluation of Two Methods to Teach a Flashcard Technique" protocol number 12082022-02 has been granted exemption by the JSU Institutional Review Board for the Protection of Human Subjects in Research (IRB).

If your research deviates from that listed in the protocol, please notify me immediately. One year from the date of this approval letter, please send me a progress report of your research project.

Best wishes for a successful research project.

Sincerely,

Jennifer Mead
Senior Human Protections Administrator, Institutional Review Board

Appendix C

Pre-Training Questionnaire and Results

#	Questions	Item Choices	Percent (%)
1	Age:_____	18	30
		19	40
		20	10
		21	10
		26	10
2	What is your year in college	Freshman	50
		Sophomore	30
		Junior	20
		Senior	0
3	What is your Major:_____	Psychology	80
		Biology	10
		Psychology/Criminal Justice	10
4	What is your current college GPA	0-1.6	0
		1.7-2.1	10
		2.2-2.6	0
		2.7-3.1	20
		3.2-3.6	40
		3.7-4.0	30
5	Do you think flashcards are a useful study tool?	Yes	90
		No	10

#	Questions	Item Choices	Percent (%)
6	How often do you use flashcards as a study tool?	Never	20
		Rarely (1 to 3 times per semester)	40
		Sometimes (about twice per month)	20
		Frequently (about once per week)	20
		Very Frequently (daily)	0
7	What is your preference regarding handwritten or digital flashcards?	Handwritten	70
		Digital	20
		I do not use flashcards	10
8	If you use digital flashcards, what websites do you use?	Quizlet	70
		Brainscape	0
		Cram	0
		Flashcard Online	0
		GoConqr	0
		ProProfs	0
		Chegg	0
		Other:_____	0
		I do not use digital flashcards	30
9	If you use digital flashcards, do you create your own cards or use cards created by others?	I create my own	20
		I use cards created by others	40
		Both	10
		I do not use digital flashcards	30
10	In the past semester, how many college instructors have recommended flashcards as a study tool in their class?	0	50
		1	50
		2	0
		3	0
		4	0
		5+	0

#	Questions	Item Choices	Percent (%)
11	In the past semester, did any college instructors give instructions on how to best use flashcards as a study tool?	Yes	10
		No	30
		Instructors did not recommend flashcards	60
12	Are you more likely to use flashcards if an instructor creates a deck for you?	Yes	80
		No	20
13	Have you ever been taught how to use the SAFMEDS technique to study flashcards?	Yes	0
		No	100

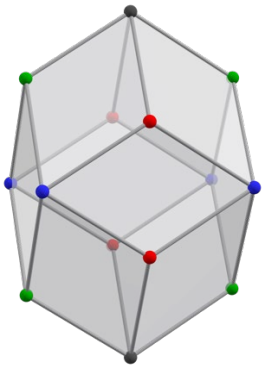
Appendix D

Post-Training Questionnaire and Results

#	Question	Choices	Percent (%)
1	What gender do you identify with?	Nonbinary	0
		Female	90
		Male	10
		Prefer to self-describe: _____	0
		Prefer not to say	0
1	The SAFMEDS protocol was easy to learn after instructions.	Strongly agree	80
		Somewhat agree	20
		Neither agree nor disagree	0
		Somewhat disagree	0
		Strongly disagree	0
2	BST was helpful in learning the SAFMEDS protocol.	Strongly agree	90
		Somewhat agree	10
		Neither agree nor disagree	0
		Somewhat disagree	0
		Strongly disagree	0
3	I think SAFMEDS would be a beneficial method to study terms.	Strongly agree	70
		Somewhat agree	20
		Neither agree nor disagree	10
		Somewhat disagree	0
		Strongly disagree	0
4	How likely are you to use SAFMEDS in a future class?	Not likely	0
		Somewhat likely	50
		Very likely	50

Appendix E

Flashcard Examples

Front of card	Back of card
 (Anthony, 2016) Pexels License https://www.pexels.com/license	Crayons
 (Lau20fe, 2018) CC BY-SA 4.0	Feline
 (Piesk, 2019) CC BY 4.0	Dodecahedron

Note. From top to bottom are examples of flashcards likely to evoke correct, incorrect, and skip responses. The in-text citations were not shown on the cards used with participants. Permission to use the "Crayons" photo (Anthony, 2016) was obtained under the Pexels License, which can be found here: https://www.pexels.com/license/.

Appendix F

Definitions of Correct and Incorrect Responses

STEP	Count as correct if…	Count as incorrect if…
1. Shuffles cards	• Shuffles cards so that order is unpredictable • Uses any method to shuffle cards, but if they split the deck they must split and recombine at least 2 times	• They do not shuffle cards • Splits and recombines deck fewer than 2 times
2. Ensures all cards are right side up	• If a card flips over, they turn it right side up again	• Does not turn card right side up
3. Starts timer	• Hits start on 1 min timer after step 2 and before completing the steps below	• Does not start the timer • Changes time to anything other than 1 min • Starts timer at wrong step (Before steps 1-2 or After step 4-11)
4. Pull card from top of deck	• Pulls a card from the top of the stack	• Pulls a card from anywhere other than the top of the stack
5. Says term or says, "skip"	• Starts saying a term or saying "skip" before flipping the card (e.g., says "uhhhhh...skip" before flipping card over; says "Red-lipped" then flips card "bat fish") • FUNCTIONALLY EQUIVALENT*: Says "pass" instead of "skip"	• Does not say anything • Says something to skip a card that is not "skip" (e.g., "uh," "I don't know," etc.) without saying "skip" before the card is flipped • Says words that are not terms (e.g., "this is...," "Oh, I know it's...," "I think it's...," etc.) without saying a term before the card is flipped • Starts saying term or "skip" after card is flipped
6. Checks response	• Flips card over so the term is visible to the participant before sorting next card	• Never flips card • Flips card over after laying down another card
7. Sorts card into correct/incorrect piles	• Places card in correct pile if they said the exact term before flipping card • Places card in incorrect pile if they said an incorrect term, didn't say a term, said "skip," or said the term after flipping over the card • FOR PRE-TRAINING ONLY: If participant does not say answer out loud: correct as long as every card is sorted into one of two piles (due to the inability to check their responses)	• Does not place the card in either pile • Puts the card in the wrong pile (e.g., said the correct term but put card in the incorrect pile)
8. Fast	• Goes through at least 20 cards in a minute	• Goes through less than 20 cards in a minute
9. Stops when timer beeps	• Stops above steps when the timer beeps or when they finish the card they were on when the timer beeped	• Does not stop when timer beeps • Stops before the timer beeps • Never started timer so couldn't stop timer
10. Counts # correct and # incorrect	• Counts the # of correct cards and counts the # of incorrect cards and writes numbers down on score sheet • Records # within one point of observers count	• Does not count # correct • Does not count # incorrect • Does not count either pile • Does not write down numbers • Miscounts the numbers by more than one digit (e.g., records 20 correct but got 18; records 5 incorrect but missed 9)

11. Records results on graph	• Correctly plots floor, corrects, and incorrects on SCC
	• Plots # within 1 point of actual # on SCC
	• FUNCTIONALLY EQUIVALENT*
	  ○ Open circle to mark corrects
	  ○ Floor extends over 2 days
		• Does not use SCC
		• Does not plot floor and/or does not plot # correct, and/or does not plot # incorrect
		• Plots incorrectly (floor, corrects, and/or incorrects)

*Functionally equivalent responses were initially scored as incorrect, but upon further review were changed to be counted as correct responses. This change is why Participant 5 had four trials in BST even though they met mastery criteria within three trials.

Appendix G

Procedural Integrity Checklists

Pre-Training

Task	Description
Gives participant questionnaire	Has participant fill out the entire pre-training questionnaire
Gives participant all materials	I.e., timer, graph, flashcards, correct & incorrect recording sheet, pencil
Tells participant to study flashcards	E.g., "Use the materials provided to study the flashcards as you would typically study them for a class."
Collects data	
Stops participant after 1 min	If the participant does not start timer, the researcher tells them to stop after 1 min
Asks participant if there is anything else they normally do when studying flashcards	E.g., "I know you only had one minute to look through the cards. Is there anything else you would do if you had more time?"

Instructions-Only

Task	Description
Gives participant all materials	I.e., timer, graph, flashcards, correct & incorrect recording sheet, pencil
Gives participant written instructions	
Ensures participant reads the instructions aloud once	Does not allow participant to skip steps Does not allow participant to look over materials until instructions have been read
Gives participant 3 min to review	Starts a 3 min timer Allows the participant to look over instructions for no more than 3 min
Does not answer questions	Does not answer questions about the flashcard technique E.g., "I am unable to answer any questions right now. Follow the instructions as you understood them."
Collects data	
Gives participant 5 min to graph	If needed, stops participants after they have spent 5 min graphing.

BST

Task	Description
Start 30 min timer for BST	Starts a separate timer for 30 min to ensure session does not run over the set time.
Brief Review of SAFMEDS and Rational	Reads the BST script with no major errors (i.e., errors that take away from the meaning of the sentence). Uses the Acronym sheet as a visual aid.
Live Model	Use a data collection sheet to ensure researcher models SAFMEDS at or above mastery criteria
Questions	Asks participants if they have any questions after watching the model.
Rehearsal	Instructs participant to try SAFMEDS
Data Collection	Uses the data collection sheet to record participant responses
Feedback	Provides feedback on the responses following the outline of the feedback sheet.
Rehearsal	Has participant rehearse again and collects data
Feedback	
Rehearsal	
Feedback	
Repeat or ends session	Continues having participant rehearse the skill until mastery criteria is met or the 30min has ended.

Post-Training

Task	Description
Gives participant all materials	I.e., timer, graph, flashcards, correct & incorrect recording sheet, pencil
SAFMEDS demonstration	Tells participant to demonstrate the SAFMEDS protocol
Collects Data	
Gives Participant Questionnaire	Has participant fill out entire post-training questionnaire

Maintenance

Task	Description
Gives participant all materials	I.e., timer, graph, flashcards, correct & incorrect recording sheet, pencil
SAFMEDS demonstration	Tells participant to demonstrate the SAFMEDS protocol
Collects Data	
Asks Questions	Asks participant questions and writes down their answers

Appendix H

Written Instructions

Step	Details
Shuffle cards	Shuffle the cards so that the order is unpredictable. Do not bend cards while shuffling.
Start 1-minute timer	You will have 1 minute to get through as many cards as you can.
Pick up card from the top of the stack	
Look at the picture on the front of the card	
Say the name of the picture or say "Skip"	If you do not know what the picture is, say "skip"
Flip the card over to check your response	
Sort card into correct or incorrect pile in front of you	**Correct:** You said the *exact* term that is written on the back of the card **Incorrect:** You said something other than the exact term, you said “skip” because you did not know the answer, or you flipped a card over before saying a term
Repeat steps 3-7 with next card	
Continue as quickly as you can before the timer stops	
Stop immediately after the timer beeps	Turn the timer off once it starts beeping
Count how many correct and incorrect responses you have	Write down the number correct and the number incorrect you got using the sheet provided
Graph your results by following the steps below.	
Find the date	The very first vertical line on the left side of the graph represents last Sunday. Each line after that represents the next day in the week (Monday, Tuesday, Wednesday...). Find the line that represents today. This is the line where you will graph your results.
Indicate how long your timing lasted	Your timing should have lasted for one minute. Look on the right side of the graph and find the horizontal line next to “1’ min.” Once you find that line, go back to the vertical line marking the date and draw a flat line on the “1’ min” line where it intersects with today’s date.
Record the number correct with a closed circle	Staying on the vertical line marking today’s date, make a closed circle indicating how many cards you got correct. To count on the graph, look at the large numbers starting with 1 on the left side of the graph. The large number indicates what to count by. From 1 to 10 you are counting by ones. From 10 to 100 you are counting by tens. If you got 12 correct, you would place the circle in between the number 10 and the next horizontal line which is the number 20.
Record the number of incorrect with an X	Using the same method to count, find the number you got incorrect and make an X for that number on the vertical line for today’s date.

Appendix I

BST Vocal Instructions Script

I am going to tell you more about the flashcard method you were given instructions on. The method is referred to as “SAFMEDS,” which stands for "Say All Fast Minute Every Day Shuffled." This acronym helps students remember some of the steps of SAFMEDS: 1. Shuffle cards, 2. Ensure all are kept right side up, 3. Start timer, 4. Pick up top card, 5. Say the term or say "skip," 6. Check response, 7. Sort into correct and incorrect piles, 8. Continue as fast as you can, 9. Stop when timer beeps, 10. Count correct and incorrect cards, 11. Graph results. The SAFMEDS method allows students to focus on increasing fluency, which is being able to respond quickly while still getting most answers correct. SAFMEDS has helped students perform better when taking tests. The graph we use for this study is called a standard celeration chart. I know it is a bit confusing because it has a lot of lines, but this graph measures fluency. This chart allows educators to see the performance of each individual student over time, which can improve teaching strategies. Next, I am going to demonstrate how to use SAFMEDS and after that you will have an opportunity to ask questions.