

Measuring SRL and Motivation Throughout a Strategy Instruction Intervention

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A college participant with a learning disability in the area of mathematics completed a strategy instruction intervention regarding mathematical problem-solving items. The participant responded to innovative interview questions regarding their approach to the mathematical problem-solving items (i.e., planning and reflecting) and their motivational beliefs (i.e., self-efficacy and interest). We used a mixed-methods case study design approach to analyze the data. In brief, results showed that the participant described more strategy steps when planning and reflecting after the intervention was introduced. Also, we observed increases in self-efficacy and interest. Improvements appeared most promising for self-efficacy, planning, and attributions. Improvements were least promising for interest. In addition to providing pilot evidence, this manuscript lays an initial step in efforts to validate continuous progress-monitoring measures of self-regulated learning and motivation. These measures may prove useful in future research addressing mathematics interventions.

Keywords: **strategy instruction, self-regulated learning, motivation, mathematics word problems, microanalysis.**

Introduction

Mathematics Difficulties and the Role of SRL in SLD

Many students with learning disabilities face mathematics difficulties. For example, students with Specific Learning Disabilities (SLD) often struggle with task organization, planning, and attention regulation (Agrawal & Morin, 2016). A mere 7% of twelfth graders with disabilities are at or above proficiency levels in math, and 75% are below a basic level (NCES, 2019). As a result, math difficulties prevent a significant portion of students from entering and completing post-secondary training (Nguyen, 2015). Moreover, many students

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report motivational and self-regulatory deficits about math (Agrawal & Morin, 2016).

Students with SLDs can be supported to succeed in math now and in the future (Montague et al., 2011). One method is to teach students to use self-regulated learning (SRL) processes such as planning, activating adaptive motivational beliefs, using heuristic problem-solving strategies to overcome challenges, and self-reflecting (Hacker et al., 2019). Among the many SRL processes, strategy instruction has been the focus of much research in part because it has shown larger effect sizes than many other academic intervention approaches (effect size = 2.55; Graham et al., 1992). SRL researchers emphasize many benefits of strategy instruction including more strategic thinking, action, and reflection, improved achievement, and enhanced motivation (Zimmerman, 2013). Although strategy instruction interventions appear to lead to achievement gains (Montague et al., 2011); researchers rarely measure perceived mechanisms of change (i.e., the strategies taught, reflection, and motivation). Even fewer studies measure mechanisms of change continuously throughout intervention administration.

The purpose of this manuscript is to serve as a proof of concept for using an innovative interview (i.e., SRL microanalysis) within a mixed-methods case study. Specifically, we use microanalysis to continuously measure changes in strategic thinking and motivational beliefs within a strategy instruction intervention. Moreover, we examine data both qualitatively and quantitatively to inform future research.

Literature Review

Self-Regulated Learning Defined

SRL entails several thinking processes, beliefs, and behaviors that occur before, during, and after learning or performing a skill. For example, before a learning task, individuals can set goals and plan to use strategies to support goal attainment. Goals and strategic plans support math achievement (Montague et al., 2011). In addition, several motivational beliefs are important prior to learning because they support adaptive goals, planning, effort expenditure, and higher achievement. In this manuscript, we emphasize self-efficacy (i.e., the belief in one's capacity to succeed at a specific task; Bandura, 1986) and interest (i.e., the level of preference or enjoyment in a task; Fredricks & Eccles, 2002). Collectively, effective regulation before beginning a task sets the stage for adaptive SRL when one is actually learning or performing (Zimmerman, 2000).

During a learning task, regulated learners can track achievements and their approach to the task. Moreover, learners can enact the strategies they identified while planning. Students can select from a variety of strategies to overcome obstacles, reduce cognitive load, bolster motivation, or manage behavior. Math interventionists often teach heuristic problem-solving strategies that emphasize multiple steps such as (a) gathering key information, (b) representing that information visually to support problem understanding, and (c) checking one's work (Watt et al., 2016). While teaching these strategies, math educators often use physical or representational models (e.g., manipulations and diagrams) to facilitate achievement gains for students with and without learning disabilities (Watt et al., 2016).

POD CHECK is one such strategy consisting of five general steps (a) propose the problem, (b) outline steps to solve the problem, (c) describe how you solved the problem, (d) defend how you know your answer makes sense, and (e) check your work. Teaching this strategy to learners has resulted in achievement gains for students with high-incidence disabilities (including math learning disabilities) at the secondary (Bundock et al., 2019) and post-secondary levels (Bundock et al, 2021).

Individuals who use strategies and monitor their progress during the task are more likely to reflect adaptively after the task (Zimmerman, 2000) by identifying perceived causes for successes and failures (i.e., attributions). These "attributions" help to close a feedback loop in which self-reflection influences SRL processes before future task attempts. Self-reflection can have negative effects when learners attribute successes or failures to uncontrollable factors, such as ability. Specifically, they may induce feelings of helplessness, diminish motivation, and reduce achievement (Clem et al., 2018). In contrast, when learners attribute outcomes to the strategies they used, or should have used, motivational beliefs may improve for future task attempts (Cleary et al., 2015).

Measuring Response to Strategy Instruction

Effective measurements are necessary if researchers are to examine whether strategy instruction interventions enhance learners' motivation and strategic planning, action, and reflection. SRL processes are most often measured with self-report questionnaires (Dinsmore et al., 2008), which entail multiple Likert scale items examining SRL processes across several contexts and tasks. Responses are averaged to generate composite scores that describe how one "usually regulates their learning." These questionnaires are typically considered advantageous because they are efficient, easy to administer and score, tend to have strong psychometrics, and predict achievement (Boaler et al., 2018).

However, self-report questionnaires may not be well-suited for progress monitoring of SRL development across repeated points in time. For example, research has shown that SRL questionnaires did not detect intervention effects that were observed by a task-specific interview (Cleary, et al., 2017). This is likely because the questionnaires are designed to aggregate SRL across multiple tasks within a domain. Thus, they may lack the sensitivity to small, incremental gains within any single task (Winne, 2010), but strategy instruction interventions usually target a single task.

The task-specific interview that we emphasize within this project (i.e., SRL microanalysis) is a semi-structured interview procedure in which questions are administered just before, during, and after a target learning task. Microanalysis interviews do not aggregate across multiple learning tasks within the math domain, as questionnaires typically would. Instead, microanalysis targets a single task (e.g., math problem solving).

Research supports the predictive validity of microanalysis interviews in a variety of domains including math (Callan & Cleary, 2018). Specifically, much of the recent research using SRL microanalysis has emphasized correlational and predictive validation studies. Also, the questions often display strong reliability (Cleary et al., 2012), and are well-aligned with SRL theory.

Study Purpose

The purpose of this study is to build upon multiple literatures. First, we build upon the literature showing that strategy instruction interventions support math achievement, develop lifelong skills, and foster motivation. Second, we build upon the SRL microanalysis literature that has shown microanalysis to predict achievement in a variety of domains. However, further research is needed to establish *how* to embed microanalysis within a mathematics strategy instruction intervention and lay the initial foundation of validity and feasibility studies. Moreover, research is needed to complete initial examinations of the stability of microanalysis measures within case study analyses.

Within this project, data is collected continuously throughout the course of a pilot, mixed-method case study, strategy instruction intervention. Specifically, we measure participants' strategic thinking while they (a) plan and (b) reflect. In addition, we measure motivational beliefs that are correlated to adaptive reflection. We address research questions (RQ) within three objectives. Our first objective deals with the increase in strategy-based language while planning and reflecting. RQ one: To what extent does a college student with an SLD exhibit increased focus on strategy steps when planning? RQ two: To what extent does a college student with an SLD exhibit increased focus on strategy steps when attributing? We hypothesize that we will observe preliminary results to be further replicated in future research with a greater number of participants.

The second objective examines the extent that motivational beliefs improve across the strategy instruction intervention. RQ three: To what extent does a college student with an SLD exhibit improvements in self-efficacy? RQ four: To what extent does a college student with an SLD exhibit improvements in interest? We hypothesize we will observe initial results that should be supported with more rigorous replication research.

The third objective is to examine the stability of the measures within baseline. RQ five: To what extent do interview questions measuring planning, self-efficacy, interest, and attributions exhibit stability in the baseline phase?

Method

Setting

The study was completed at a public university within the Intermountain West of the United States. All intervention and data collection sessions were conducted one-on-one between researchers and participants. Screening, baseline, and the first 10 intervention sessions were conducted in person until the COVID-19 pandemic halted in-person research. As a result, the remainder of data collection was conducted over video-conference. This paper is part of a larger project, and a detailed discussion of achievement gains has been published within a prior manuscript (Bundock et al., 2021b).

Participants and Screening

Researchers distributed a flier through the university disability resources email list-serve. Individuals interested in participating contacted one of the researchers, who asked initial screening questions to assess eligibility (college enrollment and disability status) and explained further details about the intervention. College students who were interested in participating then scheduled an appointment to complete screening assessments.

Two measures were used to determine participant eligibility for the studies including (a) a rate of change (ROC) assessment and (b) the Woodcock Johnson Tests of Achievement- Fourth Edition (WJ-IV; Schrank et al., 2014). The ROC assessment was a researcher-created measure consisting of six ROC word problems. Each problem was based upon the slope intercept equation ($y = mx + b$), and each problem entailed a variation on the equation (e.g., missing m versus missing y). Participants received up to 1 point for each of the following: writing an accurate equation, finding the correct answer, creating a table that included at least 3 correct pairs of values, setting up a graph, and accurately graphing at least 3 points. The second screening measures were the applied problems subtest and calculation subtest from the WJ-IV (Schrank et al., 2014), which is a norm-referenced and standardized test of achievement for individuals ages 2-90+. Overall, the math subscales evidence high reliability (.88 - .94).

Participants were eligible for the study if they (a) had a learning disability that affected math performance, (b) scored at or below the 25^{h} percentile on either the Applied problems or Calculation subtests of the WJ-IV ACH, or (c) earned less than 50% of points available on the ROC assessment. One college participant (pseudonym "Ada") was determined to be eligible to participate.

At the time of this study, Ada was a white, 21-year-old female. She was in her second year of college majoring in Special Education. Ada received services through the university Disability Resource Center and reported that she received special education services for math under the category of SLD when she was in K-12 school. Her highest level of math coursework in high school was Secondary Mathematics II, and she earned average grades of C's in her high school math classes. Ada was not enrolled in a college math course during the current study. Regarding the screening measures, Ada scored 40% (12 points) on the ROC assessment, performed at the bottom 10th percentile on the Applied Problems subtest (WJ-IV), and the bottom 8th percentile on the Calculation subtest (WJ-IV).

Materials and Measures

SRL Microanalysis Interview

Multiple times within baseline, intervention, and maintenance phases, Ada responded to four SRL interview questions situated within a mathematical problem-solving task. First, Ada would complete a preview item to orient her to types of problems (ex: *Jordan is taking a self-paced online course to learn guitar. His course expires in 8 days. He has already completed 24 lesson units. The course has a total of 48 lesson units. On average, how many lesson units should Jordan complete per day?*). Next, Ada responded to interview questions assessing her self-efficacy, interest, and strategic plans prior to completing three more similar word problems. After completing the problems, Ada reported her attributions for performance.

Self-Efficacy. Ada responded on a Likert scale to the following prompt, "Using this scale [Show Cue Card A], where one means that you are 'Not At All Sure' and seven means that you are 'Very Sure'… how sure are you that you can complete all three of the next math problems correctly?" A similar item displayed strong reliability and predictive validity in prior research (Callan et al., 2021).

Interest. Following the self-efficacy item, Ada responded on a Likert scale to the following prompt, "Using this scale [Show Cue Card B], where one means that you are 'Not At All Interested' and seven means that you are 'Very Interested,' how interested are you in doing these next problems?" A similar item has shown divergent validity (Renninger & Hidi, 2011).

Planning. Next, Ada's plans to use strategies to support problem completion were assessed by asking, "What can you do to help you do well on these problems?" Ada was prompted a maximum of two times, "Is there anything else that you can do to help you do well on the problems?" to ensure that she reported her full response. Prompts were not delivered if Ada reported a non-answer (e.g., "nothing, I don't know, or that's it"). Ada's qualitative responses were later coded quantitatively by identifying the number of strategy steps she listed (see Appendix A for a list of strategy steps coded). Interrater training is described within the procedures section below, however, reliability was 93.7%. The item and procedures are consistent with prior microanalytic research (Callan & Cleary, 2018).

Attributions. Ada's attributions for her performance were assessed by responding open-endedly to the following prompt, "If you got any of the three problems incorrect, what is the main reason?" Similar to the planning item, Ada was prompted up to twice, "Are there any other reasons?" to ensure that her full answer was provided. Ada's responses were later coded by counting the number of strategy steps stated (see Appendix A for a list of strategy steps coded). Interrater training is described within the procedures section below; however, reliability was 95%. This item is similar to prior microanalysis measures, which significantly predicted achievement (Cleary et al., 2015).

Study Design

The study design mirrored an ABC (i.e., baseline, intervention, maintenance) single case research design. This ABC design was selected because the intervention targeted an academic skill acquisition, in which a return to baseline (i.e., reversal design) is inappropriate.

Baseline. Ada started baseline after providing consent to participate and meeting the established eligibility criteria. During the baseline phase, Ada met with an interventionist three times per week, but did not complete any intervention activities. Instead, Ada completed ROC assessments during all baseline sessions (ROC outcomes are reported in a separate study by Bundock et al., 2021). In addition, Ada completed an SRL microanalysis interview during one session each week for a total of three SRL interviews.

Intervention. During the intervention phase, Ada continued to complete SRL microanalysis interviews, but also completed a 12-lesson intervention (three sessions per week) instructing how to use the POD CHECK strategy, manipulatives, and diagrams to solve ROC word problems. The POD CHECK strategy was introduced with a graphic organizer and reviewed during each session. The graphic organizer and prompts for the POD CHECK strategy were gradually faded throughout the intervention. During each intervention session, the interventionist used a procedural checklist to ensure each step was completed. Each intervention session began with a brief review of previously taught concepts (or prerequisite skills, for Lesson 1), followed by explicit instruction of new concepts, consisting of modeling (interventionist demonstrates one problem), guided practice (interventionist and Ada complete 2-3 problems together), and independent practice (Ada completed 1 problem, with assistance and feedback as needed). At the end of each lesson, Ada completed one problem independently, which the interventionist checked and provided corrective feedback as needed. Following these lesson procedures, Ada completed either a ROC assessment (two times per week) or a microanalysis interview (one time per week).

Maintenance. The maintenance phase began after all intervention sessions were completed. At this time, Ada continued to complete SRL interviews or ROC assessments one to three times per week, but no intervention nor feedback was provided. Ada completed three SRL interviews during maintenance.

Procedures

Interviewers, Training, and Fidelity

An Assistant Professor of Special Education who previously taught high-school special education mathematics developed the intervention and trained a doctoral student interventionist. All intervention sessions and interviews were conducted by the Assistant Professor and doctoral student. Interventionist training consisted of didactic instruction in key intervention components, modeling how to solve ROC word problems using manipulatives, diagrams, and the POD CHECK strategy, and practicing each lesson while trading interventionist and participant roles. Interventionists self-evaluated their fidelity of implementation by checking off steps on a procedural checklist unique to each lesson. Average fidelity was 99.7% (range 96.9-100%). Interobserver Agreement (IOA) was calculated by comparing fidelity checklists that the doctoral student and Assistant Professor completed independently for 75% of sessions and was 99.6% on average (range 99.6-100%).

SRL interviewers were trained to administer SRL microanalysis interviews by the first author. Following a didactic presentation, all interviewers practiced the interview independently before completing a practice administration with the first author. Interviewers needed to complete all steps of the interview 100% correctly prior to data collection. The first author examined procedures for 25% of interviews completed and found that procedures were completed with 100% accuracy.

Data Analysis

We quantitatively and qualitatively analyzed the data via visual analysis of graphed data for strategic planning, attributions, self-efficacy, and interest. Specifically, we examined the graphs for level, immediacy of effect, trend, and variability.

Results

RQ One: To What Extent Did Ada Exhibit an Increased Focus on Strategy Steps When Planning?

The results (Figure 1) indicate that the mean number of planned strategy steps (i.e., level) increased immediately in intervention (2.33) from baseline (.67) but dropped slightly during maintenance (2). Trend analyses showed a positive slope for intervention (0.33) that was equal to that of baseline (0.33), but greater than maintenance (0). Variability was similar within baseline (*SD* = .58, *Range* = 0 to 1) and intervention (*SD* = .58; *Range* = 2 to 3) and completely stable within maintenance (*SD* = 0; *Range* = NA).

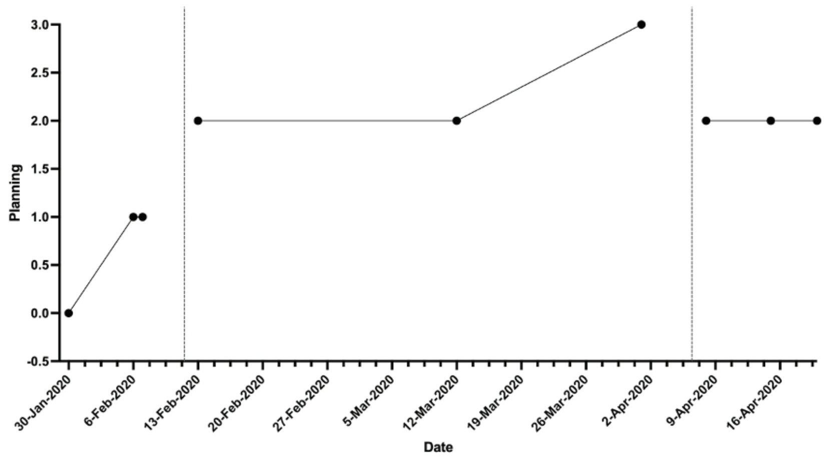

Figure 1. **Number of Strategies Steps Included in Plans Across Strategy Instruction Intervention Phases**

RQ Two: To What Extent Did Ada Exhibit an Increased Focus on Strategy Steps When Attributing?

Ada's mean level of attributions increased immediately from baseline (0) to intervention (1.33) but dropped during maintenance (0.66; see Figure 2). There was a flat trend during baseline, an increasing trend during intervention, (0.33), and a decreasing trend during maintenance (-0.66). Variability analyses indicated greater variability for intervention (*SD* = .58, *Range* = 1 to 2), and maintenance (*SD* = 1.15; *Range* = 2 to 0) compared to baseline (*SD* = NA; *Range* = NA).

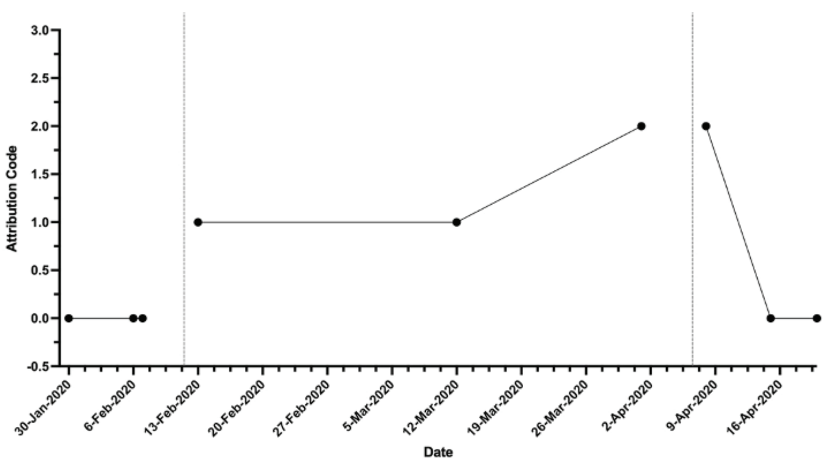

Figure 2. **Number of Strategies Steps Included in Attributions Across Strategy Instruction Intervention Phases**

Level analyses indicated that mean self-efficacy increased from baseline (1.33 out of 7) to intervention (3) and continued to increase within maintenance (5.67). An increase in self-efficacy was observed immediately in the intervention phase (first session; see Figure 3). Trend analyses showed that there was a positive slope during baseline, intervention, and maintenance. The slope was identical for baseline (0.33), intervention (0.33), and maintenance (0.33). Variability was greater within intervention (*SD* = 1, *Range* = 2 to 4) compared to the baseline (*SD* = 0.58, *Range* = 1 to 2) and maintenance (*SD* = 0.58, *Range* = 5 to 6).

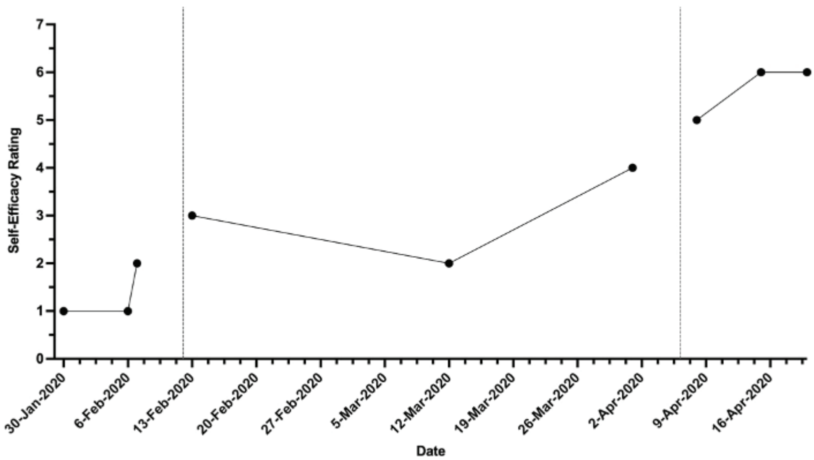

Figure 3. **Self-efficacy Ratings Across Strategy Instruction Intervention Phases**

RQ Three: To What Extent Did Ada Exhibit More Adaptive Self-Efficacy? RQ Four: To What Extent Did Ada Exhibit an Increase in Interest?

Level analyses indicated that the mean interest increased from baseline (1) to intervention phase (2) but dropped slightly within the maintenance phase (1.67). The intervention gain occurred after the second intervention session (see Figure 4). Trend analyses showed that the slope for intervention phase (0.66) was larger than the baseline phase (0) and maintenance (0). Variability was lower within baseline (*SD* = 0, *Range* = NA) compared to intervention (*SD* = 1, *Range* = 1 to 3) and maintenance (*SD* = 1.15, *Range* = 1 to 3).

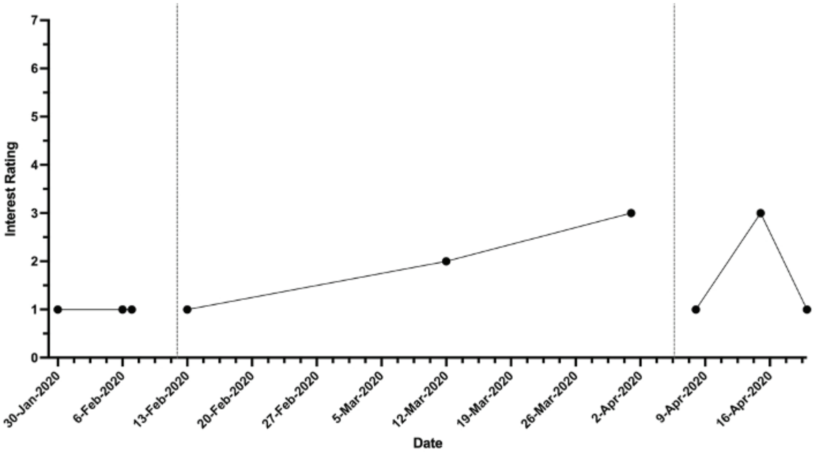

Figure 4. Interest Ratings Across Strategy Instruction Phases

RQ Five: Are Microanalysis Measures of Planning, Attributions, Self-efficacy, and Interest Stable within Baseline?

Within baseline, the planning item and self-efficacy items both displayed slight positive trends (0.33) and some variability (planning *SD* = .58; *Range* = 0 to 1; self-efficacy *SD* = 0.58; *Range* = 1 to 2). The interest and attributions items exhibited no trend nor variability within baseline.

Discussion

This manuscript examined multiple objectives. First, we examined the extent to which participants reported greater focus on strategy steps when planning and reflecting throughout the course of a strategy instruction intervention. Given that strategic planning and strategic reflection are theoretically linked to improved motivation; we explored whether motivation improved across the implementation and maintenance of the intervention as well. Next, we examined the stability of microanalysis measures within baseline. This manuscript contributes to the literature by providing initial data, establishing a first step as a proof of concept, and by extending microanalysis interview research to novel mathematical tasks.

Progress Monitoring SRL Intervention Gains Throughout Intervention

Regarding objectives one and two, we acknowledge the inherent limitations of a single participant study upfront and recognize that our project is an initial step in a larger line of research. With that stated, we interpret our findings to provide some initial support to warrant further study. We interpret that the greatestfuture support may be found for self-efficacy, planning, and attributions. We interpret that there is less potential to improve interest. We discuss the findings for each construct in greater detail below.

Improvement of Strategic Planning Across Phases

Some aspects of this case study data support an increase in strategic planning following the introduction of the intervention. For example, Ava planned to use a greater number of strategy steps during intervention compared to baseline. However, some data did not support a relationship between the intervention and increased strategic planning. Specifically, the increase in level was not fully maintained, and the trend was similar within baseline and intervention. Regarding the similar trendline in baseline and intervention, research suggests that individuals with learning disabilities do attempt to be strategic; however, without direct instruction they tend to select less effective strategies (Botsas, 2017). Given the similar trend lines and associated features of learning disabilities, we re-examined Ava's responses qualitatively. Ada reported higher quality and more intervention-specific strategies during intervention compared to baseline. For example, during baseline, Ada made vague references to, "check her work", while the language she used during the intervention mirrored the POD CHECK terminology (i.e., "check for common mistakes, make sure she identified the y intercept correctly"). During future research, we recommend that qualitative coding carefully consider the specificity of strategic planning responses in a similar fashion.

Another important finding from our qualitative analysis relates to the completeness of the strategic planning. Although the POD CHECK intervention included 13 possible strategy steps, organized within 5 broader actions; Ada only listed three of the steps. Perhaps future research should use microanalysis interview data to direct interventionists to engage in reteaching when participants have not mastered the strategy. Future research may also explore if some individual strategy steps are potent enough to affect significant achievement gains.

Improvement of Attributions Across Phases

Regarding attributions, some of our findings suggest more strategic reflection following the introduction of the intervention. For instance, there was an immediate increase in level and trend from baseline to intervention. These results complement past research indicating that individuals who are taught to use strategies more often attribute setbacks to insufficient strategies (Cleary et al., 2006). For example, students who were taught a basketball free throw strategy were more likely to attribute successes and failures to the strategy (Cleary et al., 2006). Our study extends this line of research into an academic domain. Some aspects of our data reduce our confidence in finding future increases in attributions due to strategy instruction. For example, the gains in attributions did not maintain. It is possible that a longer intervention may be beneficial to create greater durability.

Improvement of Self-Efficacy Across Phases

Some data suggest that self-efficacy improved following intervention introduction. For example, there was an immediate increase above baseline, and the increase maintained. In contrast, the trends were equal across all phases, which lowers our confidence in finding future effects in multiple participant studies. Self-efficacy ratings continued to increase during maintenance, which may suggest the need for a longer intervention for maximum effects. It may also mean that the intervention initiated an effect that continues to increase post-intervention. Finally, it could mean that the intervention played no role in self-efficacy improvements, and our findings were merely a coincidence. More research, with a greater number of participants as control, is needed to better understand the long-term maintenance effects.

Improvement of Interest Across Phases

We interpret the weakest potential link between the intervention and interest. Although there was an increase in level and trend, the increases returned to baseline levels, and Ada's highest interest rating was relatively low (3 out of 7). These less substantial findings for interest may corroborate some prior research suggesting that interest is less malleable than other motivational beliefs. Although educators can elicit "situational interest" by posing an intriguing question or novel learning experiences; personal interests are based on a longer history of experiences that may be more resistant to change compared to self-efficacy, especially after adolescence (Hoff et al., 2018).

Baseline Stability of Microanalysis Measures

Our third objective was to examine the stability of microanalysis measures within baseline. We found that the interest and attribution measures showed no variability within baseline, whereas the planning and self-efficacy measures indicated some variability (self-efficacy *SD* = 0.58, *Range* = 1 to 2; strategic planning *SD* = .58, *Range* = 0 to 1). We also observed slight upward trends within the baseline phase for both planning and self-efficacy. Ratings on the self-efficacy item can span from one to seven, whereas scores for the strategic planning item could range from zero to 13. Considering the overall potential response ranges, we interpret the variability and small baseline trends as support for the appropriateness of using microanalysis interviews within mixed-method case study research studies.

In addition to baseline stability, it is also relevant to discuss the observed pattern of self-efficacy ratings during intervention and maintenance. Ada's self-efficacy increased immediately after the introduction of the intervention, but then decreased for one session before returning to an upward trajectory that continued through the maintenance phase. This pattern of development (i.e., an initial increase, followed by a decrease, and then a subsequent increase) could depict regular measurement variation, but could also depict two possible learning concepts, "U-shaped learning curves" or the "Dunning-Kruger effect." Research regarding U-shaped learning curves indicates that skill acquisition may decline after an initial learning period before increasing again (Carlucci & Case, 2013). In contrast, the Dunning-Kruger effect describes a temporary cognitive bias in which more novice learners initially overestimate their confidence before displaying a confidence reduction as they begin to "know what they did not know", and then finally an increase in confidence (Dunning, 2011).

We decided, post-hoc, to compare Ada's self-efficacy ratings with her achievement data that was previously published (Bundock et al., 2021) to determine if the temporary self-efficacy decline and subsequent increase corresponded to a concurrent achievement decline (i.e., a U-shaped learning phenomenon) or better corresponded to a Dunning-Kruger effect.

An achievement decline was not observed concurrent with the self-efficacy decline, and the decline in self-efficacy ratings was a reduction in the accuracy of self-efficacy ratings. Considering this data, we interpret, with caution, that the decline in self-efficacy may be better explained by a Dunning-Kruger effect. Our data does not speak to the prevalence of a Dunning-Kruger effect in response to strategy instruction interventions. If future research were to discover how and when this pattern occurs, it could have important implications for interpreting single case design research in which self-efficacy is an outcome. That is, if a temporary decline is a natural, or necessary, part of the self-efficacy developmental trajectory, then traditional methods for evaluating single case design intervention effects could underestimate true effects or deem effective interventions as ineffective. Future research might consider if effect size calculations should omit self-efficacy declines, identify the typical duration of time that declines occur, and if self-efficacy returns to baseline naturally if interventions are terminated early.

Further Contributions of This Manuscript

In addition to addressing specific research questions, this study contributes to the literature in multiple ways. For example, our project is an initial step or a "proof of concept" of *how* to effectively progress-monitor mechanisms of change throughout a strategy instruction intervention. This is important for both the authors' future research endeavors and benefits the broader field of strategy instruction. Specifically, strategy instruction interventions are often used by educators and researchers to address many academic needs. Moreover, strategy instruction interventions have been shown to produce some of the largest effect sizes among academic interventions (effect size = 2.55; Graham et al., 1992).

One of the most robustly researched strategy instruction interventions is Self-Regulated Strategy Development (SRSD; Graham et al., 1992), which empowers learners to succeed by intertwining strategy instruction and tenants of self-regulation. The bulk of empirical evidence for SRSD has addressed the academic skill of writing; however, some researchers have successfully applied SRSD to mathematics as well. The measurement techniques we used within this manuscript could be embedded within SRSD, and other similar interventions, to track intervention effectiveness, parcel out mechanisms of change, identify typical "dosage" requirements to produce change, and provide interventionists with formative assessment data.

Another contribution of this manuscript is the further extension of SRL microanalysis to a novel math topic (i.e., ROC). Most of the prior literature using SRL microanalysis interviews has targeted motor tasks (e.g., dart throwing, volleyball serving), and the literature that has applied microanalysis to academic tasks has primarily addressed writing (Schunk & Swartz, 1993), test taking (DiBenedetto & Zimmerman, 2013), and general math problem solving (Callan & Cleary, 2018). ROC is a novel application of microanalysis.

Limitations

There are notable limitations to this study. The use of a single participant is the most significant limitation, which makes it impossible to make causal determinations about our data. We caution that without the control of multiple participants, our results should not be interpreted as more than preliminary data which we interpret to "warrant further study." This study was completed with a college student with a disability in the context of a ROC intervention. Thus, we caution against generalization of our findings to other areas of math, other academic domains, participants of different ages, or disability statuses. The use of self-report measures carries inherent limitations; however, the measurement of internal processes may require self-report methodologies. Future research would be strengthened via triangulation of data with multiple measurement methods such as observation, teacher ratings, and self-report. A longer intervention, longer baseline, and longer maintenance phases would also help to disentangle some questions (e.g., would a longer intervention result in better maintenance? Would a longer intervention result in more complete use of the intended strategies?). Additionally, the shift from in-person to video sessions due to COVID-19 could have influenced participant engagement in a positive or negative direction. Thus, we further caution the interpretation of results. We did not measure all possible SRL processes or motivational beliefs that might be impacted by a strategy instruction intervention. Thus, this line of research is far from complete.

Conclusion

Overall, our study provides an initial step in a longer line of research to better identify methods to progress-monitor the results of strategy instruction interventions. Our results provide initial support that we believe warrants further study. The results of this manuscript should not be interpreted as evidence of causal effects of the intervention. Future research would require a greater number of participants to make causal inferences. Instead, this manuscript outlines measurement methods that future research could use within more rigorous designs.

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