Teacher Action Research: Teaching Self-Regulation in the Context of Learning Multi-digit Multiplication in Upper Elementary Special Education Students

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In 2017, 60 % of 4th grade students and 67 % of 8th grade students performed below "proficient" on the National Mathematics Achievement Test (National Assessment of Educational Progress, 2017). Furthermore in 2015, 4th grade students in the United States ranked 35 in industrialized nations in mathematics achievement; while 8th graders ranked 25th (U.S. Department of Education, National Center for Education Statistics, 2017). Considering these statistics, teachers may need to consider different methods for teaching mathematics.

Research shows that learning multi-digit multiplication and division computation strategies based on operation properties and knowledge of place values that can be understood or flexibly derived by students is an effective strategy to teaching these complex skills in special education (Baroody & Dowker, 2003; Woodward, 2006; Schulz, A. 2018). In fact, research demonstrates that advanced calculation strategies based on conceptual reasoning (which enables metacognitive regulation) can lead to automaticity of mathematical computations (Baroody & Rosu, 2004; Woodward, 2006; Crowley, Shrager, & Siegler, 1997). Even though applying digit-based procedural memorization to solve multi-digit computation is often difficult for higher grade students (Anghileri, 2001; Hickendorff, 2013), many teachers still rely on this traditional approach. (Ambrose, Baek, & Carpenter, 2003).

Another consequence of the aforementioned traditional approach is that it does not foster self-regulated learning skills that are often lacking in struggling students (Butler & Schnellert, 2015). Self-regulated learning is typically described as the ability of a student to independently manage his or her own behavior, cognition and environment in order to set, pursue, monitor, and adjust the use of a strategy to achieve an academic goal (Reeve, Ryan, Deci, & Jang, 2008; Buzza & Dol, 2015; Buzza & Allinotte, 2013). Teaching students how to self-regulate can lead

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Commented [MOU2]: Excellent introduction

Commented [MOU3]: In the special education literature, there is a great deal of support for using both procedural and conceptual instruction. The general consensus is that rote memorization is necessary for building fluency, but it is not sufficient and should be paired with conceptually based instruction.

to success in and out of school (Cleary, 2015; Winne & Hadwin, 2008; Zimmerman & Schunk, 2001; Boekaerts, Pintrich & Zeidner, 2000; Schunk & Zimmerman, 2008).

Commented [MOU4]: You did a nice job connecting self-reguglation to math instruction.

Teachers usually do not teach self-regulation skills because they feel they do not have the time (Wehmeyer, Agran, & Hughes, 2000). This is unfortunate because developing these skills can help increase self-efficacy and motivate struggling students to remain academically engaged (Solberg et al., 2012; Maag, et a. 1993 and Maag 1992; Schunk & Ertmer, 200). Furthermore, research shows positive short-term and long-term outcomes when students are taught strategies to develop self-regulation. The short-term outcome of self-regulation interventions is increased academic accuracy, productivity, and on-task behavior for students with ADHD (e.g., Reid, Trout, & Schartz, 2005), learning disabilities (e.g., Reid, 1996), and emotional-behavioral disorders (Mooney, Ryan, Uhing, Reid, & Epstein, 2005). The long-term outcome of teaching self-regulation skills is that it can reinforce the underlying, mutually supporting attributes that are needed for self-regulation described in Table A1 (Montague & Applegate, 1993a; Montague & Applegate,1993b; Swanson & Jerman, 2006; Montague, 2007):

Research on Self-Regulation in Mathematics

In order to develop effective self-regulated learning interventions for multi-digit multiplication instruction, I analyzed research on effective self-regulation interventions with an emphasis on math instruction for struggling students. Many of the studies on this topic are single case studies with multiple baselines. Although the generalizability of single-case research can be limited, when the cumulative body of research is considered, there are clear guidelines for effective self-regulation intervention strategies. First, I describe what researchers have determined to be the most effective components to self-regulation intervention followed by more detailed information on how to help students set goals and apply metacognitive processes.

Different self-regulatory strategy instruction techniques have been developed by researchers for elementary, middle, and high school level. Most of them follow the same basic steps and vary only in the content of the checklists and the difficulty of the material covered (Montague, 2007). According to Montague (2007) and Harris & Graham (1993), the following are the basic components to effective self-regulation interventions for math:

- Collaborate with student to determine goals and establish a baseline performance level.
- Model self-regulation strategies in context.
- Have students verbalize self-regulation strategies.
- Provide self-recording cards, cue cards, or prompt sheets that students can use to self-monitor or self-instruct until they are successful at accurately completing the task.
- Have students maintain a visual record of progress.
- Fade cues and prompts as students become more competent in using self-regulation.

One component of self-regulation is self-instruction. Self-instruction is when a student verbalizes the steps they need to perform (using a checklist as a guide, if needed). Self-instruction has been shown to improve accuracy, productivity and generalization for solving math computation problems for elementary students with learning disabilities (Wood, Rosenberg & Carran, 1993; VanLuit & Naglieri, 1999) and is associated with the development of metacognitive skills (Kroesbergen and Van Luit, 2003). Furthermore, research has suggested that teacher mediated self- coping peer modeling in which students watch their peers effectively self-monitor can be one of the most useful instructional methods for struggling math students since it can increase both self-efficacy and accuracy (Schunk & Hansen, 1989, 2013; Schunk Hanson, & Cox, 1987; Zheng, Flynn & Swanson, 2013).

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The Role of the Teacher When Developing Motivation and Metacognition

Although it is common for teachers to view themselves as purveyors of information who are primarily in control of their students' academic activities, research has shown that when teachers shift their role more towards a collaborator and cognitive coach, students are more likely to develop self-regulation skills (Buzza, & Dol, 2015). For example, several studies have indicated that middle school and high school students with LD benefit from strategy instruction that promotes metacognitive processes, specifically in mathematics (e.g., Hutchinson, 1993; Maccini & Hughes, 2000; Montague, 1997a, 1997b).

Butler, Beckingham and Lauscher's (2005) research demonstrated how teachers can guide students to utilize metacognitive skills to develop their own strategies for solving problems. This is primarily done by using questioning that encourages the student to articulate their understanding and develop their own strategies that they can then record for future use. The teacher questioning and the students explaining also elucidates their misunderstanding and refines their metacognitive skills. Table A2 provides examples of the types of questions that teachers can encourage students to start asking themselves at each stage of self-regulation (adapted from Butler, et. al. 2005).

Effective Goal Setting

Effective goal setting informs all other aspects of self-regulation and can enhance self-efficacy, motivation, focus and achievement. (Chadsey-Rusch, 1992; Puustinen & Pulkkinen, 2001; Schunk & Ertmer, 2000; Locke & Latham, 2002). The most effective goals are specific, challenging, short-term, and valued by the student (Bandura, 1989; Locke & Latham, 1990; Locke, Shaw, Saari, & Latham, 1981). Goals should also ensure students can experience success so that students can develop a sense of self efficacy which usually results in improved motivation and focus (Schunk & Ertmer, 2000).

Furthermore, research suggests goals set with a mastery-orientation (i.e., focus on personal improvement and mastery of concepts) rather than performance orientation (e.g., focus on grades or competition) leads to positive self-regulatory behaviors in students with learning disabilities (Sideridis, 2005). Customized checklists, and cue cards are an effective way to clearly define measurable goals and enhance strategy implementation, self-instruction, self-monitoring and self-evaluation (Dunlap and Dunlap, 1989).

Commented [MOU6]: You did a nice job providing relevant background information to contextualize your study.

Purpose and Research Question

As a special education teacher at a small private school, many of my past students and all current upper elementary students have significant difficulty in self-regulation and are lacking in most, if not all, of the underlying attributes that support self-regulated learning. I have been primarily trained to use direct, explicit instruction. Given the emphasis on direct skill instruction, there is less time to devote instruction to self-regulation skills that will contribute to their confidence, motivation and success in many areas of their lives (Cleary, 2015; Winne & Hadwin, 2008; Zimmerman & Schunk, 2001; Boekaerts, Pintrich & Zeidner, 2000; Schunk & Zimmerman, 2008).

The purpose of this action research is to use interventions that provide an opportunity for my students to apply self-regulation skills in the context of learning multi--digit multiplication. Therefore, my research questions are as follows:

- Does instruction in self-regulation improve students' accuracy in solving multi-digit multiplication problems?

- Does instruction in self-regulation improve students' rate of task completion when solving multi-digit multiplication problems?
- Does math instruction based on promoting self-regulation improve a student's ability to carry out the three main steps to self-regulation as described by Butler et. al (2005): 1) planning, 2) performance and monitoring 3) self-evaluation?

Commented [MOU7]: Very clear research questions; nicely done!

Specific Guidance on Teaching Multi-digit Multiplication Strategies

Following the Concrete Representational Abstract (CRA) sequence is an effective approach for teaching struggling students how to solve calculation problems (Flores, Hinton, & Strozier, 2014). It involves the following steps: (1) start with demonstrations using **c**oncrete materials (e.g., place value blocks), (2) provide explicit instruction to teach students how to use **r**epresentational images to convey the concept (e.g., drawings), and (3) teach students how numbers and symbols are used to convey the concept in the **a**bstract (Flores, et al., 2014).

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Commented [TS9R8]: I have found useful information from Montague for self-regulation in math as it pertains to word problem solving, but not multi-digit multiplication. This is why I used Montegue in the literature search for self-regulation.

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Commented [MOU11]: Montaguge has done a lot of work in this area and would be worth citing, as she considered a leading scholar in the special education in this area.

Bobis (2007) described using the area model approach, which involves applying the commutative property of addition and multiplication and the distributive property to help a struggling 6th grade school student learn how to solve multi-digit multiplication problems. An example is provided in Appendix A. The area model approach would be particularly helpful for my students not only because it can make sense to my students and thus elicit metacognition, it also decreases the need for memorizing abstract procedures and enable students with low math fact fluency and recall how to use the tools they need for computation.

Method

Setting and Student Background

I teach three students their core classes, including mathematics, at a small private school. Pseudonyms have been used to protect their privacy. Anne and Michelle attend full time, while Darlene is attending school Mondays, Tuesdays, Wednesday and Fridays while Thursdays she is homeschooled. Table A3 describes each student based on cognitive assessments and other student records.

These students have been working on applying place value and the base ten system to solve addition and subtraction problems, but they have not mastered solving complex applications of these computations. For example, they have difficulty mentally adding numbers like 230 + 100 without prompts to remind them that they can do it without paper and pencil. They are familiar with the commutative property of addition and multiplication and how to show single digit multiplication with arrays, but at this time, have not learned about the distributive property.

Commented [MOU12]: Nice use of a specific example.

Many of my past students and all of current upper elementary students are lacking in some of the underlying attributes that support developing self-regulated learning described in Table A1. This affects their ability to successfully implement the three steps of regulation described by Butler et al. (2005). Table A4, describes my perception of their current level of performance on these three steps based on student records and observation.

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Since they all have difficulty with math accuracy and/or fluency, executing multistep processes and describing their mathematical thinking, learning multi-digit multiplication will provide them the necessity and opportunity to apply a variety of effective self-regulation skills to perform the three main steps to self-regulation asking and answering effective questions, as described by Butler et al (2005).

Teaching Methodology

I will use the area model rather than the traditional method since it requires less math fluency and procedural memory; it eases the use of tools and scaffolds; and since it is conceptually-based it eases the use of the CRA steps, recommended by Flores, et al. (2014). These conditions will provide students the opportunity to apply their metacognitive skills to effectively plan, perform and self-evaluate. First I will pre-teach or provide a review of the following foundational concepts:

- Provide daily review of multiplication facts using the adaptive program on Math Facts Pro.com for a few months prior to lesson.
- Review adding numbers based on 10s (e.g., 120 + 200 = ?; 1000 + 550 + 8 = ?).
- Review the following vocabulary: commutative property of addition and multiplication, addend, factors, products, sum. (These are stored in their math reference notebook and on word wall as provided in Appendix A).
- Review numbers in their expanded form (e.g., 37 = 30 + 7)
- Pre-teach multiplying single digit numbers by numbers based on ten (e.g., 10 X 5; 2 X 300) and the distributive property using visual supports and manipulatives.

After conducting a semi-structured pre-interview that includes a probe as outlined in Figure B1. I will provide direct instruction followed by guided practice applying the area model for solving multidigit multiplication problems using the CRA model proposed by Flores, et al. (2014) by using graphic representations, then graphic organizers (examples provided in Figure C1, C2, C3). After the students understand these concepts, I will provide direction instruction and guided practice on filling out the self-reflection and goal setting sheets (Figures C4, C5), presenting their work using mock student examples with mistakes (Figure C6 and C7). Using these examples, I will also provide direct instruction and guided parctice on using all of the scaffolds including reference sheets (Figures C1), graphic organizers (Figures C2 and C3), word wall (Figure C9) and the “Silly Mistake” checklist (Figure C10). Instructional materials and scaffolds that include examples of guided practice and “graded student work” such as self-reflection and goal setting sheets, reference notes, graphic organizers, multiplication tables, “Silly Mistake Checklist” and a word wall and are provided in Appendix C.

When introducing the self-evaluation and goal setting sheets, I will provide the following explanation:

> Not only will you be learning a different way to multiply multiple digits that should make more sense to you, you will be learning how to ‘work smarter, not harder’ by learning how to approach mistakes and challenges in such a way that you can learn from them (reference the mistakes are an opportunity for learning poster). You will also be learning how to show and explain your work and help each other identify what tools you need to be successful. Because of this you will be doing fewer problems, but then you will talk about how you solved them and evaluate how you might improve or challenge yourself when you’re ready using these self-evaluation and goal setting sheets. The self-evaluation and goal setting sheets will also be graded since it is so important to reflect on your challenges and successes whenever you are learning new things.

Student modeling, Self-instruction and Self-Monitoring

Since research indicates that students benefit from teacher-mediated peer modeling, (Schunk & Hansen, 1989, 2013; Schunk Hanson, & Cox, 1987; Zheng, Flynn & Swanson, 2013) self-instruction (Schunk & Hansen, 1989, 2013; Schunk Hanson, & Cox, 1987; Zheng, Flynn & Swanson, 2013) and self-monitoring (Butler, et. al., 2005). I will employ the following steps after the completion of the four problems on a daily basis:

1. After I describe how to solve one problem on the board, the students will take turns describing how to solve the remainder of the problems. In the case, they have different problems because they progress to 2 X 3 multiplication at different rates, I will check for accuracy any remaining problems without telling them where the errors are so that they have an opportunity to find their own errors.
2. I will provide prompts, if needed to get them to explain their reasoning using mathematical language. Examples of prompts include: What property allowed you to write the numbers in the expanded form on the area model? What do you call the numbers inside the area model again? What operation did you use the fill in the grid? What operation did you use to fill find the final product?
3. Students who got a problem wrong will make the corrections on their paper using a pen and a highlighter.
4. They will then fill out the self-reflection and goal sheet (Figures C4, and C5).
5. I will review the self-reflection and daily goal setting sheet with them and put a "P" for prompt, if it is necessary to give a specific prompt. An example of a graded and ungraded self-reflection and goal setting sheet are provided in Appendix A.

Commented [MOU14]: Please give examples)

Commented [MOU15]: When will students set goals?

The daily self-reflection and goal setting sheets are designed to provide a scaffold for students for the type of questions that students who self-regulate ask themselves, as described by Butler, et. al. (2005) and presented in Table A2. Furthermore, research by Dunlap and Dunlap (1989) suggests that checklists are an effective way to clearly define measurable goals and enhance strategy implementation, self-instruction, self-monitoring and self-evaluation; all traits of a student with strong metacognitive skills.

Data

Semi-structured Interviews

I will conduct semi-structured student pre- and post- interviews as described in Appendix B.

Commented [MOU16]: Is this part of your instruction or part of data collection?

Commented [TS17R16]: Data collection and instruction.

Commented [TS18R16]:

Daily Computation Accuracy

Daily computation accuracy on multi-digit multiplication problems will be measured based on a total of 10 points per problem, 4 problems per day, 4 times per week over 3 weeks. The grand total of possible points will be 40 for 4 problems per day based on the following parameters:

1. Factors correctly placed on grid in expanded form: 2 points for 2 X 2; not graded for 2 X 3
2. Correct partial products filled in grid: 2 points for each correct partial product
3. Addition of partial products: 2 points for lining up correctly, as applicable; 2 points for correct final answer. Total points: 4. If student uses mental math and correctly solves the problem, they will receive 4 points.

Commented [MOU19]: Please provide examples of these in a figure.

An example of grading is provided in Figures C2 and C3.

Daily Task Completion

Daily task completion will be measured as the percent completed on 4 problems.

Commented [MOU20]: One thing to consider is that this will not be a whole percent if students don't finish 3 out of 3. Consider changing to 4.

Commented [TS21R20]: I changed it to 4. Thanks for the suggestion.

Self-Reflection Accuracy

After correcting their work, students will be required to fill out the self-reflection and goal setting sheets daily that includes error analysis, and goal setting components, as shown in Appendix A and I will review it with them and keep track of the number of prompts they need to accurately fill it out. Self-reflection accuracy will be measured as a percent. The percent will be determined giving 2 points to each of the 10 questions/subquestions and subtracting 1 point for each prompt given to the student.

Commented [MOU22]: This is where you will direct instruction…you will want to include modeling and guided practice in both the procedures of self-reflection and the purpose.

Teacher Observation

After each day, I will write a brief description of what I did and how the students responded in terms of demonstrating more self-regulation attributes and their attitudes and behavior. In addition, I will reflect on the following questions**:**

- When they presented their work, how well were they able to explain their reasoning?
- How confident do the students seem?
- Are they able to share their ideas and ask meaningful questions?
- Do they realize when they need to change a strategy without prompting?
- Do they take appropriate breaks or ask for help when needed?
- Are they overwhelmed to the point of giving up?

After three weeks of implementing this plan, I will conduct a post-semi structured interview as described in Figure B2.

Data Interpretation

Table D1 summarizes how I will use my data to evaluate the answers to my research questions.

Example Results

Daily Accuracy, Task Completion and Self-Reflection Accuracy will be reported as a bar graph with a trend line for each student to provide a visual representation of academic growth and the relationship between these factors (Figure D1). Changes in the difficulty of the problems will also be noted.

Commented [MOU23]: It might be nice to include a graph of each one for each student; we can talk about this in the spring.

Sample Discussion

Figure D1 suggests that there is a positive trend in Anne's growth in accuracy not suggests that her ability to perform the three steps of self-regulation has improved: plan, perform and monitor, and self-evaluate. Although this was not part of the research question, results of the pre- and post-interview indicate that Anne liked learning the new area model because it was easier than the traditional model, which suggests she thought it was helpful to learn multi-digit multiplication in a way that made more sense to her. She also realized the need to increase the difficulty level after day 4 without prompting. This suggests that her motivation and self-efficacy is strong and she is gaining the ability to set her own goals during the planning phase. She indicated that she did not like filling out the self-evaluation or goal setting chart because it was too much work. According to teacher observations, she used her multiplication chart for some of the harder facts, and she was able to describe her steps during her student modeling session with prompting to use her words and not just write down what she did. One of her models had a miscalculation, which the Michele corrected. Thankfully this did not bother Anne and Michele seemed to be pleased to help out a classmate.

Next Steps: Modify self-regulatory instruction for long division using partial products based on results. Possibilities include simplifying the self-evaluation form.

Limitations

Being the teacher and researcher and including largely qualitative data, this research has a large potential for bias. Furthermore, the sample size, student population and qualitative nature don't allow for generalization of results.

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Appendix A

Tables

Table A1

Underlying Attributes and Skills that are Necessary for Successful Self-Regulation

Attribute	References
Self-efficacy: the belief in the one's ability to be successful at something. Increased self-efficacy increases motivation.	Schunk and Zimmerman 2008; Boekaerts, Koning & Vedder, 2006
Accurate achievement attributions.	Schunk & Zimmerman, 2008
Executive function: the ability to focus, plan, organize and implement one's efforts to achieve a goal	Bryan, Burstein, & Bryan, 2001
Metacognition: the ability to reflect on one's mental process and adjust strategies accordingly	Boekaerts, 1997, Winne & Perry, 2000; Belfiore & Hornyak, 1998

Table A2

Steps of Self-Regulation and Corresponding Examples of Self-Questioning

Steps	Questions Students May Ask Themselves
Plan	What is my goal? Is it easy or hard for me? What tools and resources do I need to accomplish this goal? What strategy am I going to use? Do I need to ask for help? What parts of this problem are tricky or confusing, which parts make sense?
Perform and Self-Monitor	Am I completing the task? Am I effectively applying a strategy? Do I need to modify or use a different strategy?
Self-Evaluation	"Did I accomplish my goal? Why or why not? What strategies or tools worked or didn't work? Why? Should I modify my strategy?

Note: Questions adapted from by Butler et al, 2005.

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Table A3

Student Background

Name	Age (years)	Weekly school attendance	Disability or Challenges	Current Math Performance
Anne	10	4 days	Autism, Speech Delay. Very low Math and Oral Expression Fluency. Low working memory. Slow processing. Resists verbal self-instruction for spelling practice. Becomes very inhibited verbally when recorded. Parents are English Language Learners.	3rd grade level. Not fluent but accurate in multiplication, addition and subtraction but knows most facts. Learned traditional 2-digit by 1-digit multiplication but doesn't remember how to do it. Currently becoming familiar with division facts.
Darlene	12	2 days	Nonverbal Learning Disability. Speech and Language Delay. Very low working memory. Resists verbal self-instruction for spelling practice. Parents are English Language Learners.	2 grade level. Not accurate or fluent in addition or subtraction. Knows, 78 out of 121 multiplication facts for 0-10. Has been introduced to traditional 2 digit by 1-digit multiplication but is unable to correctly solve these problems consistently.
Michelle	11	4 days	Aspergers/ADHD Excellent verbal skills Takes medication for anxiety and ADHD. Math identified as causing "extreme" anxiety. Visual and auditory. processing challenges. Difficulty following directions. Difficulty asking for and taking breaks when needed. Difficulty with whole body listening due to	3rd grade level Highly accurate with addition and subtraction facts but not fluent. Knows most multiplication facts for factors 0-11 but is not fluent. Knows division facts for the following divisors: 1, 2,3, 4, 5, , 10, 11. Has learned both methods of multidigit multiplication and prefers the area model. Complex math concepts are pre-taught 1-1 to reduce classroom anxiety.

	trichotillomania caused by medication.	

Table A4

Present Level of Underlying Attributes and Skills that are Necessary for Successful Self-Regulation

	Current Level of Performance: High/Medium/Low		
Attribute	Anne	Darlene	Michele
Plan	Low Has difficulty identifying learning goal.	Low Has difficulty identifying learning goal and the level of difficulty of problems.	Low Becomes anxious when a new learning goal is presented. Math identified as an "extreme" source of anxiety in student file.
Perform and Monitor	Medium Good task completion but poor monitoring. Requires oversight to accurately follow through on multi-step processes. Frequently doesn't use tools. Strong resistance to oral explanation of mathematical thinking.	Low Good task completion but poor monitoring. Requires oversight to accurately follow through on multistep processes. Doesn't realize when she needs to ask for help or use a tool/strategy. Frequently makes careless mistakes. Frequently doesn't use tools.	Low Frequently requires oversight and timed 2-minute breaks to stay focused on lessons and assignments due to self-stimming behavior. Frequently doesn't ask for help or use a tool/strategy. Motivation fluctuates from low to high on a hourly basis based on whether she is distracted by something else or if she perceives a task will be too difficult or if she is not happy with how she is doing. Self-monitors for accuracy.
Self Evaluation	Low Frequently erases answers before figuring out where the mistake occurred.	Low Frequently erases answers before figuring out where the mistake occurred.	Medium Rarely appropriately asks for breaks or help when needed. Frequently erases answers before figuring out where the mistake occurred.

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Appendix B

Semi-structured Pre- and Post- Interview

Notes will be taken during the one-on-one, semi-structured pre-and post- interviews. These questions will be asked **before** we start the unit to determine a qualitative baseline skills for understanding and implementing multidigit multiplication and their ability to implement the three steps in self-regulation: 1) plan, 2) perform and monitor 3) self-evaluate.

1. Have you ever learned multi-digit multiplication? (Show them the following examples: 27 X 6, 45 X 61, and 371 X 295).
    a. If yes, ask the following questions:
        1. How well did you understand how to do it? Really well, Sort of, Not at all?
        2. What tools did you use? (Provide them with any tools they state.)
        3. Do you think you still remember how to do it?
        4. Are you scared or excited to learn it again?
    b. Probe: Give them the following problem and ask, "Can you explain to me how to solve one of these as if I am a student?" 49 X 68 = ? ; If too hard, ask them 27 X 6 = ? If correct, ask them to solve three more problems.
        1. Evaluate students' answer in terms of the following components:
            1. Traditional or Area Model
            2. Ability to explain why they do each step when prompted.
            3. Level of comfort performing the steps.
            4. Note any scaffolds used (e.g. multiplication table or graphic organizer).

Figure B1 - Teacher-student semi-structured pre-interview.

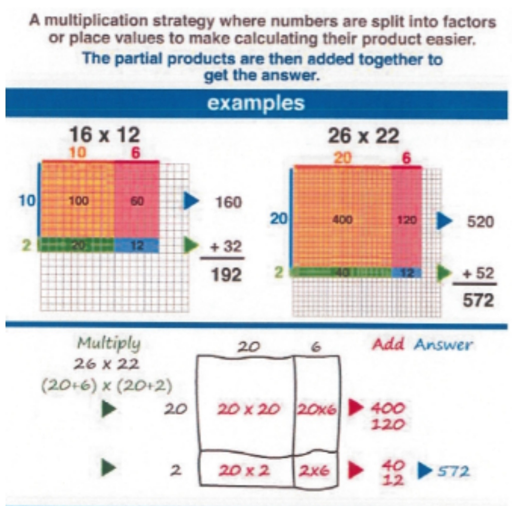
Notes will be taken during the one-on-one, semi-structured pre-and post- interviews. These questions will be asked after we have completed 3 weeks of independent practice on multidigit multiplication to determine if there is any growth in their ability to implement the three steps in self-regulation: 1) plan 2) perform and monitor 3) self-evaluate:

1. How do you feel about learning multi-digit multiplication?
2. What do you think helped you the most?
3. How well do you think you understand how to do multi-digit multiplication? Really well, Sort of, Not at all?
4. What do you think was the hardest for you or what do you think got in your way? (Note if following prompts are needed: Did you ever feel overwhelmed or distracted and gave up? Did you keep making silly mistakes?
5. What tools/strategies might be helpful for you in the future when you need to do multi-digit multiplication? (Note if the following prompts are needed: Reference sheets, multiplication/addition chart, graphic organizer etc.)
6. We are going to learn long division using a similar method that to the area method of multiplication instead of the traditional method that is hard to understand. How do you feel about that?

Appendix C

Examples for Direct Instruction, Guided Practice, Scaffolds and Scoring

Direct Instruction Reference Sheet



Guided Practice Example for Student-created Reference Sheet

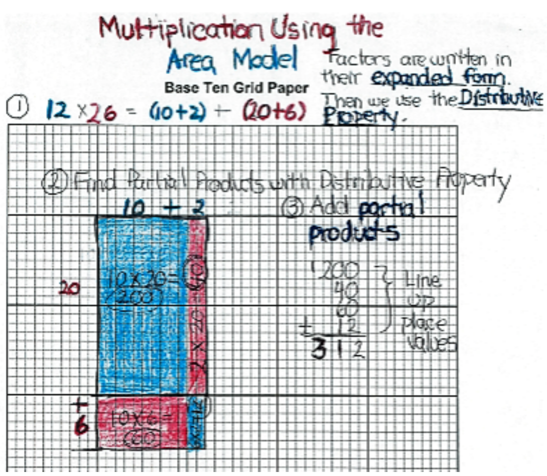


Figure C1. Graphic representations of the area model for direct instruction and guided practice.

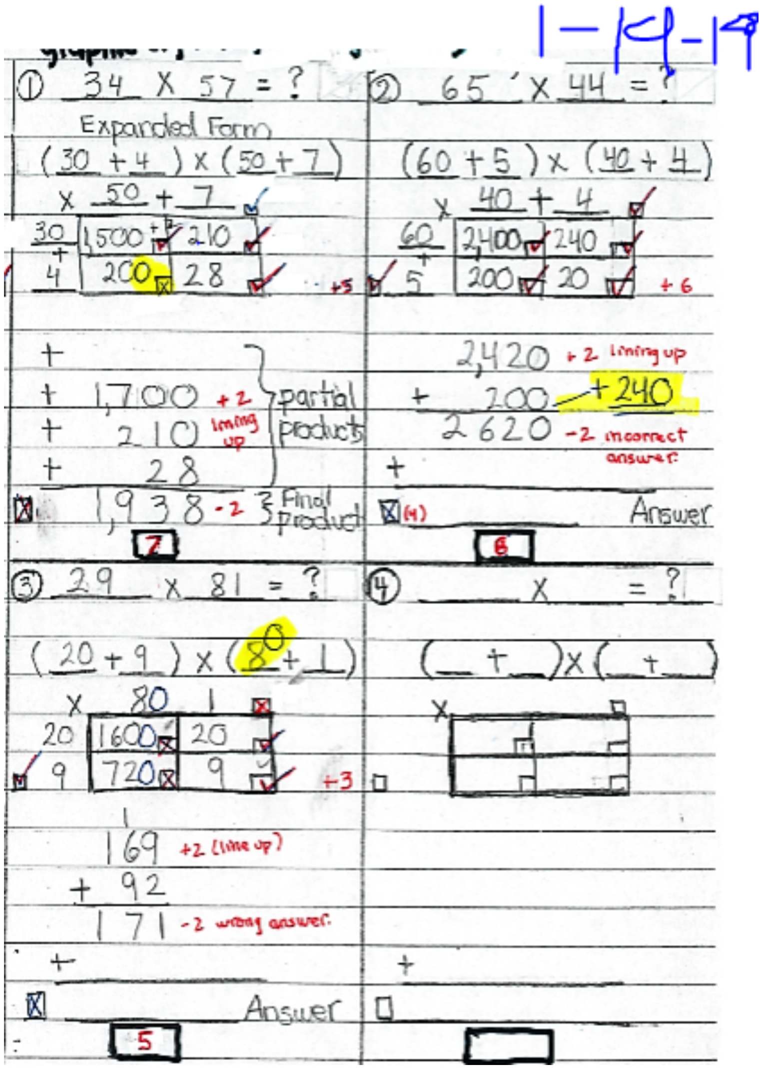
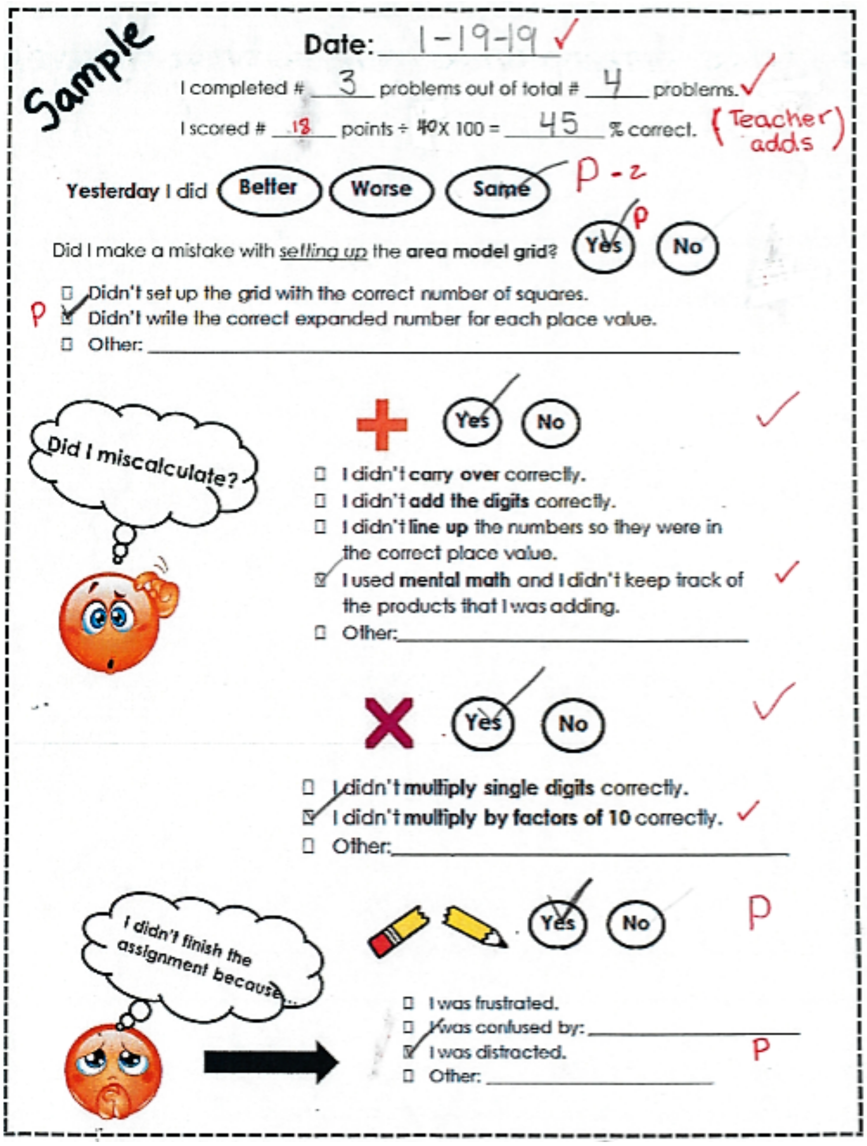


Figure C2. Example of 2 X 2 graphic organizer, grading and guided practice for self -evaluation sheet, goal setting and scaffold use.



Sample

Date: 1-19-19 ✓

I completed # 3 problems out of total # 4 problems. ✓

I scored # 18 points ÷ 40 X 100 = 45 % correct. (Teacher adds)

Yesterday I did Better Worse Same P - 2

Did I make a mistake with setting up the area model grid? Yes P No

- ☐ Didn't set up the grid with the correct number of squares.
- ☑ Didn't write the correct expanded number for each place value. P
- ☐ Other: ____

Did I miscalculate?

+ Yes No ✓

- ☐ I didn't carry over correctly.
- ☐ I didn't add the digits correctly.
- ☐ I didn't line up the numbers so they were in the correct place value.
- ☑ I used mental math and I didn't keep track of the products that I was adding. ✓
- ☐ Other: ____

X Yes No ✓

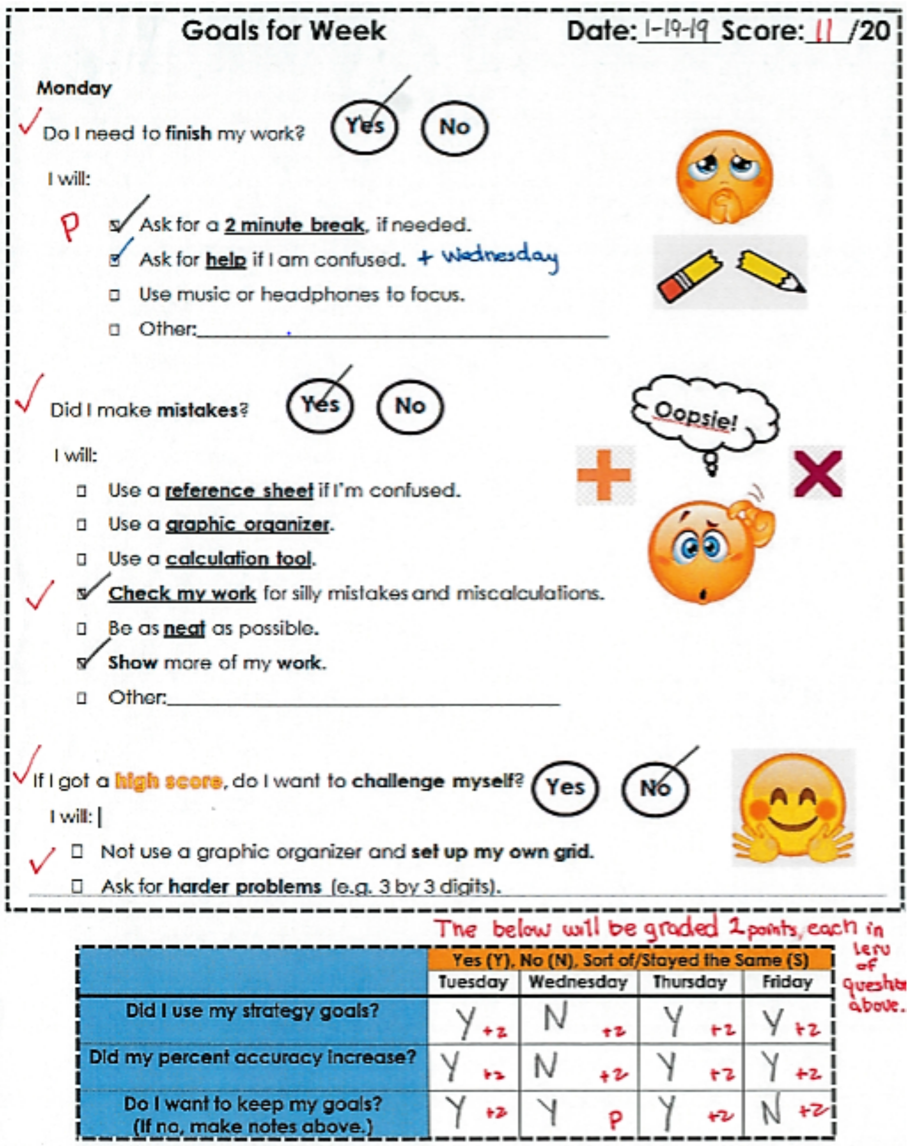
- ☐ I didn't multiply single digits correctly.
- ☑ I didn't multiply by factors of 10 correctly. ✓
- ☐ Other: ____

I didn't finish the assignment because...

Yes No P

- ☐ I was frustrated.
- ☐ I was confused by: ____
- ☑ I was distracted. P
- ☐ Other: ____

Figure C4. Daily self-reflection based on example in Figure C3.



Goals for Week Date: 1-19-19 Score: 11 /20

Monday

Do I need to **finish** my work? (Yes) (No)

I will:

- [x] Ask for a **2 minute break**, if needed. P
- [x] Ask for **help** if I am confused. + Wednesday
- [ ] Use music or headphones to focus.
- [ ] Other:______

Did I make **mistakes**? (Yes) (No)

I will:

- [ ] Use a **reference sheet** if I'm confused.
- [ ] Use a **graphic organizer**.
- [ ] Use a **calculation tool**.
- [x] **Check my work** for silly mistakes and miscalculations.
- [ ] Be as **neat** as possible.
- [x] **Show** more of my **work**.
- [ ] Other:______

If I got a **high score**, do I want to **challenge myself**? (Yes) (No)

I will:

- [ ] Not use a graphic organizer and **set up my own grid.**
- [ ] Ask for **harder problems** (e.g. 3 by 3 digits).

The below will be graded 2 points, each in leiu of question above.

	Yes (Y), No (N), Sort of/Stayed the Same (S)			
	Tuesday	Wednesday	Thursday	Friday
Did I use my strategy goals?	Y +2	N +2	Y +2	Y +2
Did my percent accuracy increase?	Y +2	N +2	Y +2	Y +2
Do I want to keep my goals? (If no, make notes above.)	Y +2	Y P	Y +2	N +2

Figure C5 Daily goal setting sheet (for 1 week) based on example in Figure C3.

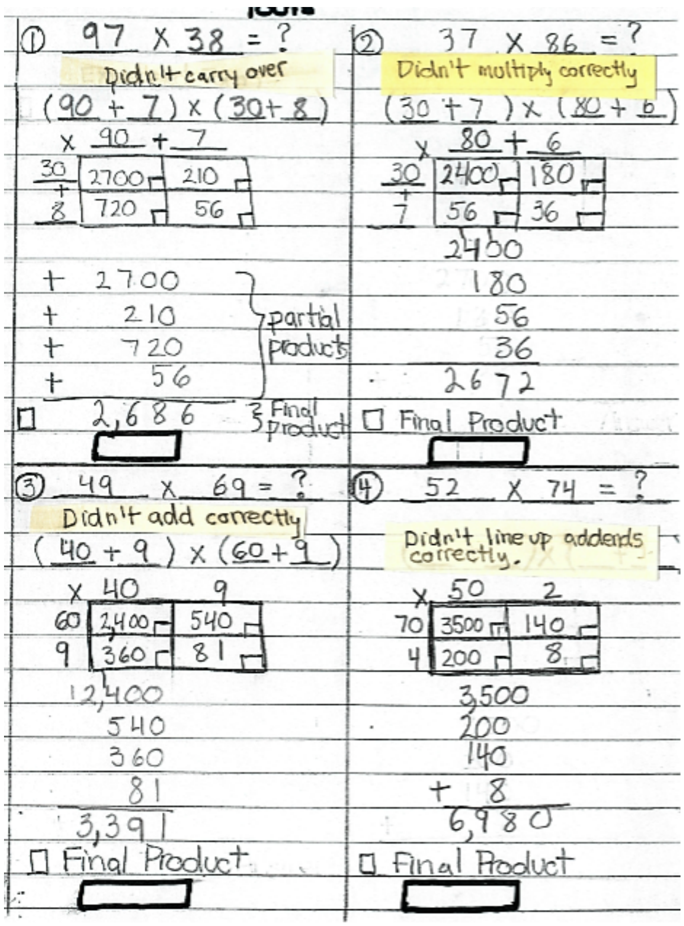


Figure C6. Graphic organizer (1 of 2) used for modeling and guided practice scaffold use, self-evaluation, and goal setting sheets. Notes on errors were removed for instruction.

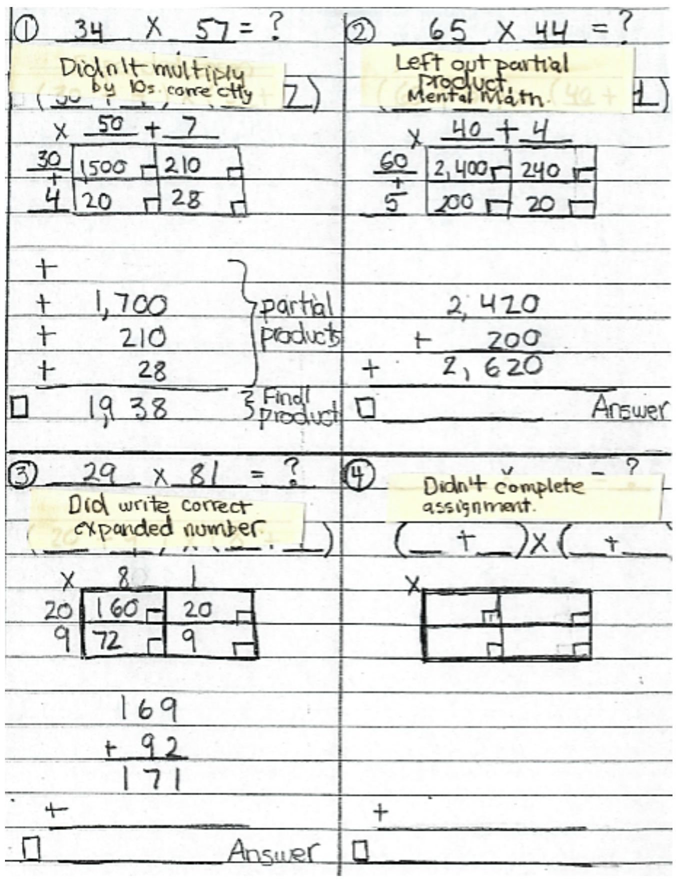


Figure C7. Graphic organizer (2 of 2). This was used for modeling and guided practice scaffold use, self-evaluation, and goal setting sheets. Notes on errors will be removed for instruction.

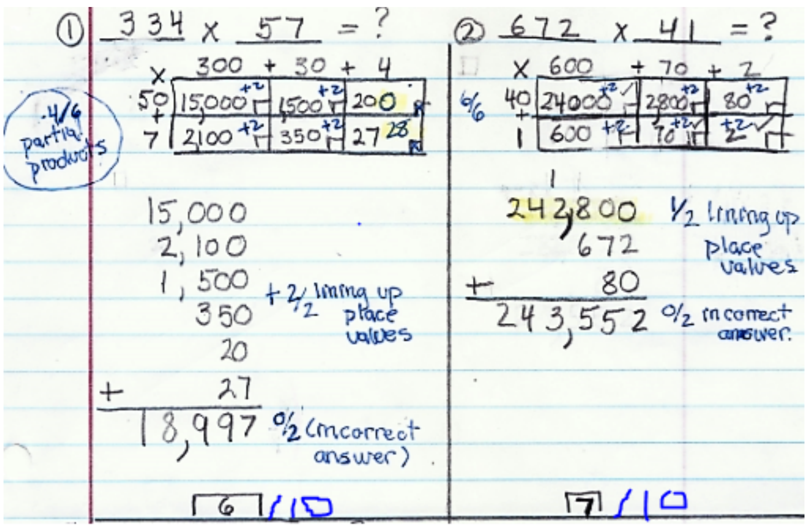


Figure C8. Example of 2 X 3 partial graphic organizer and grading

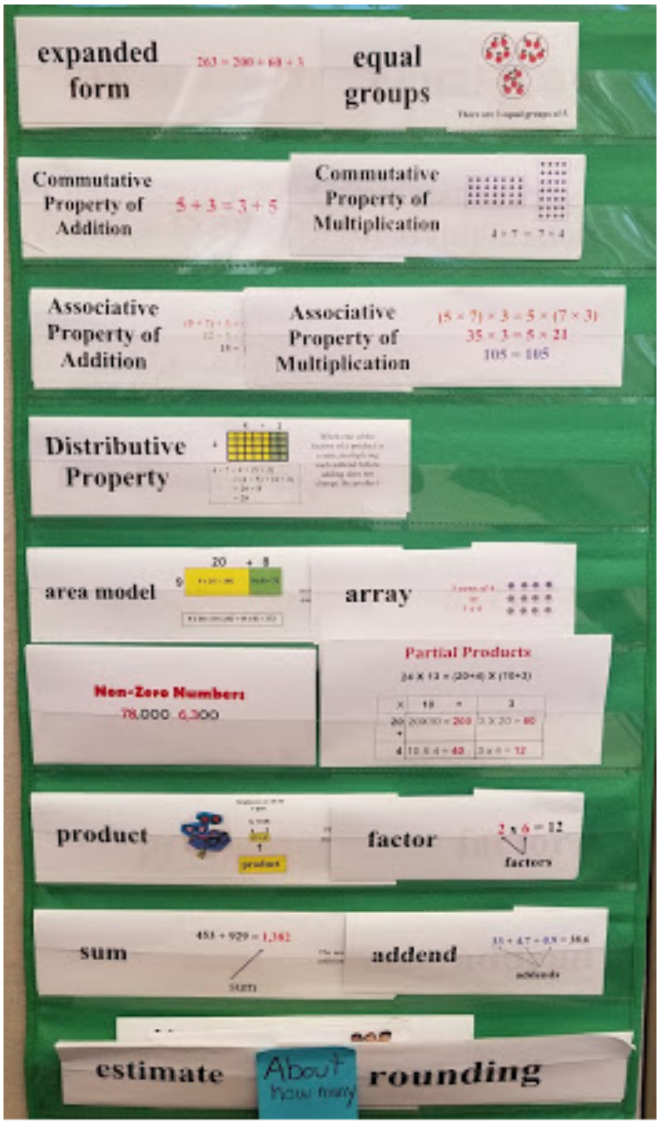
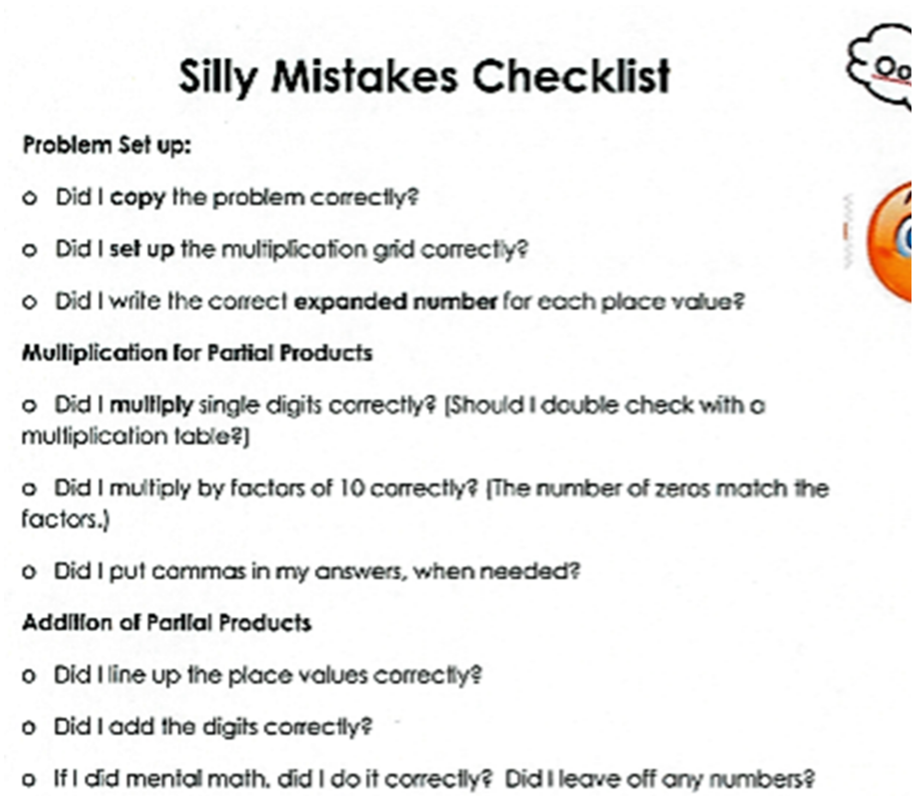


Figure C9..Word wall. For use during instruction and peer modeling-self instruction.



Silly Mistakes Checklist

Problem Set up:

- Did I **copy** the problem correctly?
- Did I **set up** the multiplication grid correctly?
- Did I write the correct **expanded number** for each place value?

Multiplication for Partial Products

- Did I **multiply** single digits correctly? (Should I double check with a multiplication table?)
- Did I multiply by factors of 10 correctly? (The number of zeros match the factors.)
- Did I put commas in my answers, when needed?

Addition of Partial Products

- Did I line up the place values correctly?
- Did I add the digits correctly?
- If I did mental math, did I do it correctly? Did I leave off any numbers?

Figure C10. Silly Mistakes Checklist. This can be used by students who tend to make avoidable mistakes.

Appendix D

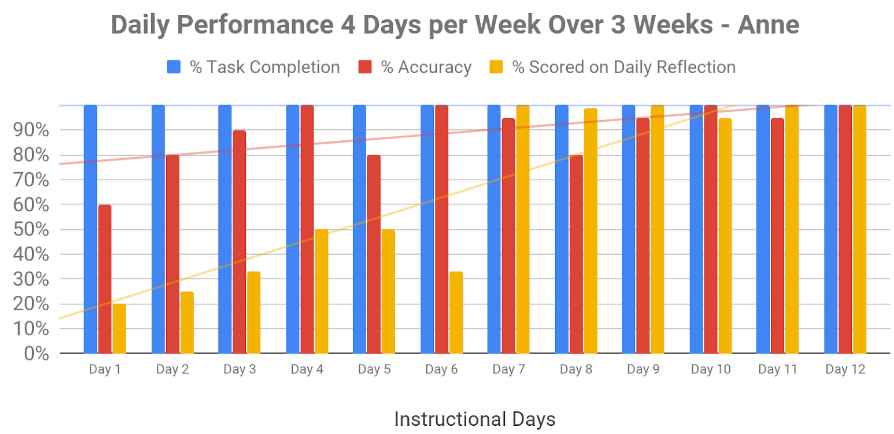
Results

Table D1
Data Interpretation Methods

Research Question	Data Interpretation
Does instruction in self-regulation improve students' rate of task completion when solving multi-digit multiplication problems?	% Task completion graphed in a bar chart with a trend line as shown in Figure 1.
Does instruction in self-regulation improve students' accuracy when solving multi-digit multiplication problems?	% Accuracy graphed with a trend line as shown in Figure 1.
Does math instruction based on promoting self-regulation improve a student's ability to: a) plan, b) perform and monitor c) self evaluate?	% Task completion, % Accuracy, Summary of Teacher Observations, Self-Reflection/Goal Setting Accuracy, Pre and Post Semi-structured interview.

Student Interview Notes (?)

Observation during student presentations (?)



Note: Anne chose to do a 3-by-3- digit problems starting on day 5. She chose to not use a graphic organizer starting on day 9.

Figure D1. Daily Performance Using Trend Lines Demonstrate Growth