Insights into Learning Disabilities 20(2), 101-122, 2023

Eva's Opportunity to Learn: A Narrative Analysis of Mathematics Instruction and Self-regulation

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This study explores opportunity to learn (OTL) during mathematics activities for a nine-year-old student girl with difficulty in mathematics. We conducted a teaching experiment comprising 15 instructional sessions. To better understand the student's OTL, our qualitative analysis focused on how she student demonstrated self-regulation in response to instructional delivery (i.e., explicit instruction and cognitively demanding tasks) and feedback (i.e., corrective, affirmative, and pressing). The student's self-regulatory behaviors indicated a highly graduated, student-centered structure with affirmative, mathematizing feedback supported mathematics learning, while other components of instructional delivery and forms of feedback did not. Thus, we provide an illustration of self-regulation as an indicator of OTL rather than as something to remediate. We argue individualized support can be facilitated by integrating instructional practices from the fields of special education and mathematics education and expanding perspectives on self-regulation, rather than holding singular commitments to particular disciplinary practices and perspectives.

Keywords: **opportunity to learn, mathematics instruction, self-regulation, mathematics difficulty, narrative analysis**

Introduction

Rethinking Opportunity to Learn

While opportunity to learn (OTL) is often discussed in terms of courses and curriculum (Walkowiak et al., 2017), another perspective on OTL considers the "relationship between an individual with both a mind and a body and an environment in which the individual thinks, feels, acts, and interacts" (Gee, 2008, pg. 81). From this point of view, OTL is supported when there is alignment between an individual's learning needs and the instructional context in which those learning needs are expressed. However, research on the learning of students who have difficulty in mathematics often aims to measure outcomes of interventions designed with a particular instructional approach (e.g., explicit instruction or cognitively demanding tasks), rarely focusing on how to harmonize the teaching-learning environment to enhance OTL. This study explored how Eva, a third-grade student aged nine who experienced difficulty in mathematics, responded to a variety of instructional approaches to identify which might best support her OTL.

Instructional Delivery and Opportunity to Learn Mathematics

There is consensus among researchers that neurodivergent students who have difficulty in mathematics typically benefit from systematic instruction (Myers et al., 2015; Fuchs et al., 2021). This includes accessible number sets, visual representations, gradually increasing complexity, and scaffolding. Scaffolding might take the form of breaking down content into manageable units (Pool et al., 2013), removing instructional support gradually (Bakker et al., 2015), and reducing the demands of a task so a child can focus on the targeted skill or concept (Bruner, 1978; Stein et al., 1996). While there is agreement on the benefits of systematicity, there is less consensus around instructional delivery (Munter et al., 2015).

Practical experience suggests that diverse students and diverse learning goals necessitate a variety of instructional approaches. However, there is a tendency among researchers to identify and argue for a single instructional approach. Many researchers, especially in the field of special education, contend that instructional delivery in mathematics must be explicit (e.g., Grigorenko et al., 2020; Powell et al., 2022). This approach is meant to develop background knowledge, provide extrinsic motivation, and support efficient learning of mathematical tasks that require accuracy and precision (Mercer et al., 1996). Typically, explicit instruction incorporates systematicity by identifying discrete components of the target knowledge or skill and these components are taught individually and sequentially (Doabler & Fien, 2013; Powell et al., 2022). The delivery format is characterized by teacher explanations and modeling which make the requirements for student performance explicit, followed by guided practice in which the teacher gradually increases the students' responsibility for completing all aspects of the task. Feedback is corrective or affirmative guidance to ensure students are following the provided model.

Other researchers, many from the field of mathematics education, contend that high-quality instruction is based in eliciting and guiding students' thinking through the use of cognitively demanding tasks (e.g., Cobb & Jackson, 2021; Stein et al., 1996). This approach is meant to support beliefs about self and intrinsic motivation, as well as support academic outcomes such as conceptual understanding and procedural fluency (De Corte et al., 2000; Rappolt-Schlichtmann et al., 2018; Stein et al., 2017). Instructional delivery is centered around tasks which are problematic for students in that they cannot apply a procedure they have already been shown and must reason about how to solve the problem (Stein et al., 1996). To provide feedback the teacher may question students about their reasoning and then "press" students by asking further questions which encourage them to extend their thinking or try a new strategy.

Feedback in this model may also mathematize students' activity, that is highlight and make explicit the mathematical nature of their work (Freudenthal, 1973). Recently, researchers have provided evidence of learning gains for students who have difficulty in mathematics using a approach which builds on student thinking (Hunt et al., 2020; Xin et al., 2016).

Some researchers have encouraged a combination of approaches (Mercer et al., 1996; Woodward & Montague, 2002), yet there is little practical guidance available as to how to accomplish this and under what conditions. We aim to explore this issue. To provide systematic instruction that allows flexibility to individualize delivery, we used learning trajectories. Instruction based on learning trajectories has had positive effects on achievement and self-regulation for students with difficulty in mathematics (Clements et al., 2020). Learning trajectories have three components – a developmental progression, learning goals based on the progression, and tasks that support progress (Sarama & Clements, 2009). The developmental progression provides systematicity by describing typical ways in which student understanding around the topic develops over time. Tasks can be designed to draw on varied instructional delivery formats, including explicit instruction with corrective or affirmative feedback or cognitively demanding tasks supported by pressing students to think more deeply or consider alternatives and mathematizing feedback which highlights mathematical properties in their activity.

Neurodivergent Students and Opportunity to Learn Mathematics

Neurodivergent students may need individualized support as they develop mathematical knowledge. Ideally, this support would align instructional delivery with an individual's learning needs. That is, the learning environment would be designed with consideration for the ways the student thinks or feels in that context.

How a student thinks or feels can impact mathematics learning in several ways. Cognitive difficulties related to mathematics achievement vary across domain-specific (e.g., quantity estimation, magnitude representation), domain-general (e.g., language processing), and executive functioning abilities (e.g., working memory, attention, inhibitory control; Ashkenazi et al., 2013; Nelson et al., 2022). Additionally, affective (e.g., emotions, anxiety) and volitional responses (e.g., motivation, inhibition) to learning environments are associated with mathematics achievement (Dowker et al., 2016; Nelson et al., 2022). Thus, a number of potential strengths and difficulties need to be considered when tailoring instructional support for a student.

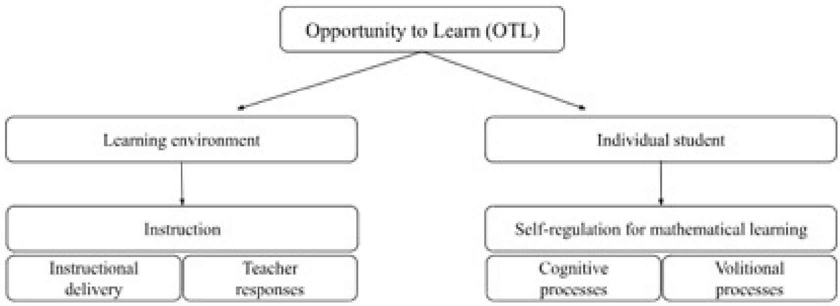
Cognitive, affective, and volitional traits contribute to self-regulation. Self-regulation can be defined as the ability to regulate one's thoughts, feelings, and behavior in order to achieve a goal (Boekaerts & Cascallar, 2006). It encompasses metacognitive awareness of processes of learning and processes of emotional, motivational, and behavioral monitoring and control (De Corte et al., 2000; Hernández et al; 2018). Studies indicate that self-regulation and mathematics outcomes are strongly related in primary grades (Hernández et al., 2018; Jõgi et al., 2016; Zee & de Bree, 2017).

Because of this relationship between self-regulation and mathematics outcomes, self-regulation is a frequent focus of research and intervention (Pandey et al., 2018). Students are described as demonstrating self-regulation when behaviors support the goal of learning (Boekaerts & Cascallar, 2006; De Corte et al., 2000; Hernández et al., 2018). Therefore, the aim of most research and intervention is to increase students' meta-cognitive awareness and ability to apply strategies for productive learning behaviors (Kuypers, 2011; Mason & Reid, 2017). However, our aim was not to change Eva's self-regulation but to describe it in relation to the instructional environment. We used these observations to make inferences about her OTL.

Self-regulation for Mathematics Learning

We adopt DeCorte, Verschaffel, and Op't Enyde's (2000) definition of self-regulation for mathematics learning. They write that a mathematical disposition is characterized by control and agency over learning and problem solving, and they identify regulation of cognition, emotions, and motivation as key elements of this disposition. Specifically, a mathematical disposition involves regulation of cognitive processes (i.e., problem solving, reasoning, planning, and monitoring) and volitional processes (i.e., motivation, emotion, and attention and inhibitory control; note affective experiences are included in volitional processes).

This definition of self-regulation aligns with the perspective of OTL as an interaction between an individual and a learning environment (Gee, 2008). DeCorte and colleagues (2000) state that the "whole reality of self-regulated mathematical learning" involves cognitive and volitional processes which are "situated against a more complex personal and contextual background" (p. 692). With this perspective in mind, we consider self-regulation in the context of instructional delivery and feedback (see Figure 1). Viewing self-regulation as agency over learning, we describe how the cognitive and volitional processes evidenced by a particular student (Eva) may have been attempts at exercising agency within the instructional conditions she was experiencing. We consider behaviors commonly associated with a lack of self-regulation, such as expressions of negative emotions, inattention, or task avoidance, as well as behaviors typically associated with mathematical learning, such as persistence and reasoning as agentic.



Note. Adapted from De Corte et al. (2000) and Gee (2008).

Figure 1. **Framework for Analysis of Eva's OTL**

Purpose

The purpose of the teaching experiment with Eva, a student who needs individualized learning support in mathematics, was to identify instructional approaches that would optimize her OTL. Our analysis addressed how she demonstrated self-regulation under different instructional delivery and feedback formats. We considered self-regulation as a form of agency in a particular learning environment, and we focused on identifying evidence of volitional and/or cognitive processes and inferring what Eva's self-regulatory behavior accomplished.

Method

Essence of the Teaching Experiment

We conducted a teaching experiment with Eva followed by a narrative microgenetic analysis. Teaching experiments apply methodological consistency within a naturalistic setting by using intentional teaching, data collection, and on-going analysis to refine a conjecture (Confrey & Lachance, 2000). This teaching experiment was guided by a conjecture that instruction responsive to the individual can facilitate learning in a student with intensive support needs. We explored which instructional delivery and feedback formats most enhanced Eva's OTL. This narrative microgenetic analysis had two important elements: (a) identifying conditions that might promote learning (Lavelli et al., 2005; Siegler, 2006), and (b) linking data to tell a plausible "story" about how learning might occur over time (Polkinghorne, 1995). We identify conditions that promote learning through observations of knowledge or behaviors and how those change over time, possible sources of change, and how widely generalized the knowledge or behaviors are (Siegler, 2006). Those observations and our inferences are connected to tell the "story" of Eva's OTL.

Participant Information

Eva is a multi-racial girl living in the western United States. She is a member of a middle-class family comprising native English speakers. During this teaching experiment, Eva was nine years old and in grade 3. Eva's mother described her as active, loving pets, and having a great sense of humor. Her mother stated that Eva felt a lot of anxiety about school and often abandoned tasks and experienced emotional distress during math class. Two years prior to this study, Eva underwent a neuropsychological evaluation that resulted in several diagnoses which might impact OTL: attention deficit with unspecified impulse-control and conduct disorder, speech-sound disorder, specific language disorder with impairments in written language and mathematics, and generalized anxiety. Eva attended a public charter school in a small city where she received individualized special education services as well as speech therapy with a focus on phonetics. She had below average scores on achievement test scores in reading and mathematics, and her Individualized Education Program included reading, writing, and mathematics goals; the mathematics goals at the time of this teaching experiment were to count to 100 and learn basic arithmetic facts. These various aspects of her identity, interests, diagnoses, and school experiences certainly have an effect on Eva's OTL. While we do not make any claims about specific causal factors related to these aspects of Eva's being, we aimed to consider all of them in designing and delivering instruction and analyzing the data.

With Eva's mother, we discussed Eva's difficulties in mathematics and ways to provide her with additional academic support without increasing her anxiety. We planned for the current study and then gained informed parent consent and student assent following guidelines established by the university's ethics board.

We aimed to conduct inclusive research. Therefore, we acknowledged our roles as participants in this study (de Bruin, 2017). We adopt the stance of integrating ourselves into this narrative, rather than positioning ourselves outside of it (Connelly & Clandinin, 2006). One of us conducted the teaching experiments in relationship with Eva and her mother, who was present for all the sessions. We negotiated goals, activities, and interactions to establish trust. As researchers, we both continue this relationship with Eva through our analysis.

Teaching Experiment Procedure

The first author conducted all the teaching experiment sessions. She has a doctoral degree in mathematics education and 18 years of experience teaching math in grades 1-8, including working with students with difficulty in whole class, small group, and one-to-one settings. The sessions took place in 2020 amidst the COVID-19 pandemic, with flexible meeting dates to allow for family needs and quarantining requirements. All sessions took place at Eva's home with Eva's mother present. There were 15 teaching experiment sessions, each ranging from 30-45 minutes. Due to the pandemic and to limit Eva's anxiety, it was not possible to have an additional researcher present during the sessions. During each session, the author asked Eva's permission to video record the activity and only recorded when Eva was comfortable with it.

The first author planned for each session using established learning trajectories and a planning protocol developed in consultation with a critical colleague. A primary consideration when planning was Eva's anxiety around number-related activities and given the importance of spatial reasoning in mathematical understanding, the author planned to use a number of spatial reasoning trajectories (Sarama & Clements, 2009). Initially, she selected either explicit instruction or cognitively demanding tasks as the instructional delivery method based on an assessment of alignment with the content. The author expected to adjust the delivery format as needed to support Eva's OTL and documented the nature of these changes and the rationale for the change.

The planning protocol included prompts for observations, outcomes, adjustments made during the lesson, and reflection on the rationale for the adjustments. The reflection regularly considered Eva's strengths and needs. Furthermore, the reflections explicitly drew inferences using the knowledge of Eva's diagnoses. In light of this documentation, along with field notes and videos of Eva's previous activities, the author chose tasks to facilitate Eva's gradual development of mathematical ideas and devised strategies to support or scaffold Eva's participation in those tasks. The author then completed the planning protocol by entering detailed plans, including goals, desired student activity, tasks, supports to achieve those goals, and rationales. These protocols were shared with two colleagues before each teaching session. One colleague, with expertise in early mathematics instruction for students with learning disabilities, advised on the tasks and supports. A second colleague, with experience with children with anxiety, advised on the plans in light of Eva's previous volitional responses. Also, the first author regularly discussed sessions with Eva's mother and sought her input on tasks and instructional approaches.

The teaching experiment began with two instructional delivery formats, explicit instruction (Powell et al., 2000) and cognitively demanding tasks (Stein et al., 1996). Explicit instruction involves explaining and modeling with a clear, simple, and organized presentation and examples of the key mathematical concepts or procedures. This is followed by guided practice opportunities. Feedback structures associated with explicit instruction are specific corrective or affirmative feedback to guide students' responses (Archer & Hughes, 2010). Cognitively demanding tasks are mathematical puzzles or contextual dilemmas for which there is no immediately obvious solution strategy. These tasks are designed to build on a student's current understanding while centering problem solving. Feedback associated with cognitively demanding tasks involves pressing questions to encourage alternative strategies or extend the student's thinking or mathematizing the student's thinking or activity (Stein et al., 1996).

Data Analysis

Data sources were the planning and reflection protocols previously described, photographs of student work, videos and transcriptions, and a post-hoc observation protocol. Videos were recorded using the Swivl © app on an Android device and stored on secure servers. The audio files were transcribed with Otter ©, and the transcribed material was then converted into a word document for editing. The editing process consisted of replaying the video file while reading through the transcription file checking and correcting errors.

The second author completed a post-hoc observation protocol for each video as a way to triangulate observations and interpretations of Eva's responses to activity. In the protocol, the author recorded a task description, student behaviors (e.g., actions, comments), teacher behaviors (e.g., explanations, length of work time offered without interruption, additional supports), and other observations. The author completed the protocol for each video. It was common to pause and rewatch segments of a video file multiple times to capture all necessary data.

To analyze these data, we used a narrative analysis adapted for microgenetic studies (Lavelli et al., 2005). This approach comprises five stages. In the first stage, we again watched the videos, creating memos of our impressions and interpretations about Eva's learning. At the end of this stage, we discussed our overall ideas and questions and generated a list of potential "frames," the specific viewpoints or phenomena which could be focal points for analysis. Our potential frames included self-regulation, instructional delivery formats, language use, geometry learning trajectories, anxiety, etc. In the second stage, we synthesized information from all data sources and wrote chronological narratives, one for each session of the teaching experiment. These narratives are descriptive and document the sequence of events. To ensure accurate and comprehensive chronological narratives, we each wrote a narrative for half of the sessions and then reviewed and revised the narratives written by the other. We recorded thoughts related to frames, explanations, interpretations, questions or reflections in a parallel set of memos.

In the third stage, we used the chronological narratives as the main data source to discuss all the frames, tentative definitions, possible configurations of frames that seemed useful ways of portraying learning. These discussions culminated in the decision to focus on three frames: spatial reasoning learning trajectories, instructional delivery formats, and self-regulation.

The fourth stage involved re-reading the chronological narratives for evidence of stability or change over time related to frames and to develop stories that synthesize information and support inferences. We gathered evidence to confirm or refute these inferences by revisiting the original data sources with particular attention to overt behaviors and strategies. Emerging stories about each frame were revised as necessary. In the fifth stage, we used the stories and evidence to create a narrative that describes how instructional delivery formats, and associated teacher responses, elicited behaviors related to self-regulation and thereby impacted Eva's OTL.

Findings

The purpose of this teaching experiment was to investigate OTL for a student who experiences difficulty in mathematics and needs individualized support. Our focus was the relationship between instructional delivery and feedback and how the student evidenced self-regulation. We found strict adherence to explicit instruction, including corrective feedback, and cognitively demanding tasks, including pressing student thinking, elicited forms of self-regulation from Eva that limited mathematics learning. We also found that a student-centered, graduated increase in difficulty with mathematizing and affirmative feedback elicited forms of self-regulation from Eva that were supportive of mathematics learning. As we describe the teaching experiment, we will use first person singular to describe the teachers' activity since the first author was delivering the instruction as well as making moment-by-moment decisions.

Instructional Delivery–Response to Explicit Instruction

I used explicit instruction with the topic of shape attributes because clear and explicit explanations and demonstrations of mathematical ideas seemed a fruitful approach for drawing attention to these concepts. The lessons focused on three attributes of a circle—a curved line, made entirely of the same curve, with no gaps or breaks. During this instruction, Eva engaged in distracting or disrupting behaviors; she changed the nature of the task when asked to do something, recruited her mother to do activities with her, or made loud noises or played with objects near her. The following transcript illustrates Eva changing the nature of the task:

> Author: Do you remember when we talked about circles before and I said they had three things?
>
> Eva: Not really but I think you might tell me. [Eva starts drawing]
>
> Author: I can tell you again because it would be hard to remember. Oh, I think you're making a circle.
>
> Eva: Yep, was that your plan?

This brief transcript illustrates two things. First, Eva indicated that she understood the lesson structure, and knew that since I will tell her the features of circles, there was no strong incentive for her to remember them. Second, it illustrates how she took over and changed the activity, offering a response other than the one asked for but one she could accomplish.

In the same lesson, Eva continued to draw circles while I tried to explain and model the three attributes. Eva participated in the lesson by answering my questions with "yeah" or "mm-hmm," drawing circles, and recruiting her mom to participate.

> Author: Can I point out why it's a circle? The three things. It's got curved lines,
> Eva: Yeah.
> Author: The second one is that the curve stays the same, the whole way around the curve doesn't change. All the same curve. And there's no breaks. No breaks. Eva?
> Eva: Yep. [drawing a circle on the paper]
> Author: [tapping and pointing to the circle] No breaks.
> Eva: [drawing another circle] That's a better one.
> Author: So we talked about something that doesn't have curves. And, like this. [drawing a shape with straight sides]
> Eva: Make a circle too, Mom.
> Author: This doesn't have curves, right? [pointing to a non-example] That's not curved.
> Eva: I want mom to do what I do.

As illustrated in this transcript, Eva's response to explicit and direct instruction was often inattentive and at times appeared perfunctory.

When her mother or I redirected her attention, she engaged in even more disruptive activity. On one occasion, she repeatedly made loud noises which Eva described as singing. She stated she was "just being herself." In another lesson in which I was using explicit instruction to re-teach attributes of circles, she began jumping and wiggling. When her mother said, "Don't do that," Eva replied, "What do you mean? I'm just jumping." When we continued to require Eva to stop her behaviors and attend to the lesson, she became agitated, and we stopped the activity.

Eva's behaviors were disruptive of the explicit instruction, and they made progress in the tasks difficult. An outcome of these lessons was that Eva would point to circles but did not name any attributes. Also, lessons took considerably longer than planned and needed to be repeated on subsequent sessions, thereby undermining the efficiency that explicit instruction offers.

We infer from Eva's awareness of lesson structure (saying "I bet you'll tell me"), defining the tasks with which she would engage, and disruptions of the lesson that Eva was displaying agentic and self-regulatory behavior. This was behavior that directed her experience away from mathematical learning that was the goal of the lesson. Volitional processes within this instructional context, such as where Eva would place her attention, motivation, and inhibitory control then greatly limited the OTL the targeted mathematics.

Instructional Delivery–Response to Cognitively Demanding Tasks

Eva responded to cognitively demanding tasks, those without a clear solution path and require problem solving and reasoning, by rejecting the task. Eva expressed negative emotions such as frustration and anger. Sometimes Eva left the room in which we were working.

During the first two sessions, I presented challenging 2D shape composition puzzles in which an outline of a picture was provided with no interior lines, requiring Eva to determine how to compose the picture by selecting pattern blocks and orienting them correctly (see Figure 2A). Eva looked at these puzzles and grabbed a few pattern blocks. It appeared she did not know where to place blocks she grabbed, and she did not apply any processes such as reasoning or trial-and-error. Instead, she dropped the blocks, left the table where we were working, and began riding a scooter on the patio next to our work area. She would only return to the task when given the option to create her own picture any way she wanted. Similarly, any time I presented a 2D shape puzzle outline for which Eva did not immediately recognize a block that could be used, she pushed the puzzle away and would not engage with it.

Note. Panel A shows 2D shape composition tasks which were cognitively demanding for Eva (she saw no apparent solution path) and which she rejected. Panel B shows examples of the highly graduated difficulty with 2D shape composition tasks which Eva attempted with increasing confidence.

Figure 2. **Eva's Progression in 2D Shape Composition Tasks**

An example of Eva's emotional response to challenging tasks comes from a 3D shape composition task using wooden blocks. The goal was to build a doghouse with features such as four walls and a roof, the context selected because of her love of pets. A challenge in this task was planning the construction of the walls so that one could place blocks for a roof. Eva was interested in this task at first. Eva's approach was to grab and place blocks at random, and she wanted to construct walls without evidence of cognitive processes such as planning. Her emotional response to this challenge is illustrated in the following transcript:

[Eva yells]
Author: What's wrong?
Eva : I hate stupid these!
Mom: What makes that stupid?
Eva: They don't balance!
Author: [placing a feelings chart on the table with a scale of five faces that range from happy to sad] I will put this out in case you get pretty frustrated with it.
Eva: Why do you not add a angry face?
Author: Do you feel angry sometimes instead?
Eva: Yeah.
Author: Well I could remake it. Another one with an angry face instead of sad.
Eva: No, you can put it here. [pointing to the middle of the scale]
Author: Put it in here? Would that be it? Are you…do you feel angry before you feel sad?
Eva: Yeah, mostly.

This interaction shows how Eva's response to the challenge involved yelling and anger. These emotions prevented her from reflecting on her activity and considering what she might do differently to construct the doghouse. With the feelings chart, Eva advocated for a more appropriate chart that matched her feelings about the task.

We again infer that Eva was showing agentic and self-regulatory behavior in response to cognitively demanding tasks. Eva rejected tasks for which she did not see an entry point, and thus she avoided experiencing failure. When she did engage with a task with which she was not successful, she communicated her feeling of anger. Again, volitional processes prevented engagement of cognitive processes such as planning and reflecting in a substantial way.

Instructional Delivery–Highly Graduated, Student-Centered Tasks

Through the process of observing Eva's responses and adjusting instruction, we found a highly graduated increase in difficulty with student-centered tasks was most supportive of engagement and learning. By highly graduated we mean small, planned incremental changes to the difficulty of a task Eva previously accomplished successfully, similar to the way explicit instruction applies scaffolding by breaking down complex tasks to focus on discrete elements. By student-centered we mean tasks which Eva could engage with that did not involve teacher explanations or modeling, similar to the way cognitively demanding tasks ground all learning in students' thinking. We began these lessons with a task she could complete successfully and then controlled the increase in difficulty to ensure the subsequent tasks were within reach.

This occurred most often in the 2D shape composition learning trajectory with puzzles that slowly increased in difficulty (see Figure 2B; see Crawford & Kernin, 2022 for more information about the mathematical content of each session). After Eva rejected more challenging shape outlines, I gave Eva a puzzle with no shared sides and easily recognizable shapes (i.e., square, triangle, and hexagon). Then, I gave Eva mini-puzzle cards, each with two blocks, gradually increasing the proportion of the shared sides and gradually introducing less recognizable shapes (i.e., trapezoid and two rhombuses). Eventually these cards only provided the outline with no interior lines. After Eva completed a few of these mini-puzzles, we offered her a larger puzzle with partial shared sides, all interior lines, and which incorporated the shapes with which she had just worked with and asked if she wanted to try it.

We saw evidence of Eva's willingness to complete the tasks and growing confidence in her ability. Eva was motivated to complete these tasks; she remained at the worktable while completing these tasks, rather than getting up and leaving the work area as she did with other tasks. Eva selected from among the tasks offered and regularly completed at least three tasks before she indicated a desire to do a different activity. Eva also showed growing confidence, eventually describing herself as "an expert" and selecting tasks she thought were challenging:

> Author: Can you choose a couple of those to do? Thank you.
> Eva: Oooh!
> Author: You want to do that one?
> Eva: Hard.
> Author: I also have some others in here that are even more hard but I thought [Eva starts talking before author finishes statement]
> Eva: This looks like a camel [begins looking for pattern blocks to fill in the shape]
> Author: A camel? It kind of does. Yes, it's got a hump on its back.
> Eva: Yep. This is hard, this is hard.
> Author: What do you think seems hard about that one?

Eva: Everything.
Author: Pardon me? What?
Eva: Everything.
Author: What do you mean "everything"? It seems like you knew what to do right away.
Eva: No I mean like it's going to be hard, hard for friends, and mom or dad, I mean that.

We also saw increased evidence of reasoning and planning in her problem solving. Eva began to select blocks intentionally. For example, in one session she tapped her finger on an exterior angle of a complex shape outline and looked for a block that might fill the angular region, which we interpret as evidence of reasoning. We also saw evidence of planning as she selected roughly the number of blocks she would need to fill a particular area of the puzzle. The following transcripts illustrates how she communicated her reasoning and meta-cognitive awareness of her problem-solving process:

Author: This is the first one you put. Do you, can you tell me why you might have picked that one to be first?
Eva: Because right here [pointing to a section of the puzzle]
Author: What did you see?
Eva: [tracing the exterior line of the puzzle with her finger]
Author: Oh, what, what's that?
Eva: Is it okay I draw, draw on this part?
Author: Sure, yeah. Would that help you tell me what you did?
Eva: mm-hmm
Author: Okay.
Eva: Well, I looked at the shape and I saw I could match something.

Eva's activity, then, showed increasing self-regulation that was supportive of mathematical learning rather than controlling the task or rejecting the activity. Eva transitioned from only completing pictures based on her own interests to completing puzzles offered to her, puzzles which drew her attention to attributes of shapes, ways of composing larger shapes, and use of transformations. Eva maintained agency by selecting from among the tasks presented those she was interested in trying. She demonstrated volitional processes supportive of mathematics learning including motivation, attention, and confidence. There was also evidence of Eva's cognitive processes including reasoning, planning, and meta-cognitive awareness.

Feedback

We analyzed how Eva responded to feedback. Eva responded negatively to corrective feedback whether it came in the form of explicit guidance (correcting an error) or questioning (asking her to reconsider her response). However, she responded positively to specific, affirmative feedback which helped her recognize the mathematics within her own activity.

When I offered corrective feedback, whether through explicit guidance or in the form of questions that directed her attention, Eva expressed frustration or anger. We illustrate such a response with the following transcript which includes both pointing to a problematic aspect of Eva's response and questioning her about it. During a 2D shape composition task that was cognitively demanding for Eva, the following occurred:

> Author: You knew just what you wanted to put there. Does that fit just right?
> Eva: Mm-hmm [indicating "yes"]
> Author: Because I don't see this side and this side lining up with a side. I see
> Eva: No this is the side with it.
> Author: Okay. [moves a block] Oh, there that looks a little bit closer now. Right?
> Eva: No, this is the side. I just put it a little over here.[moves the block back]
> Author: Okay.
> Eva: This is the side it's supposed to be at.
> Author: But you know what I see? I see lots of gaps and holes. I wonder if there's another way [Eva makes a noise like, "grrr"] that might work better. Is there another way that will work better?... [Eva starts humming] I just want you to show [moves a block]… Does that work? …[Eva makes a noise like, "grrr"]
> Eva: This is right. [moving the block back]
> Author: This is right? [Eva makes a noise like, "grrr"] How do you know that?
> Eva: [sounds as though she is growling out the words] It looks just like it.
> Author: It looks just like it?
> Eva: [yelling] Yes it does.
> Author: Okay. Okay, all right.
> (Simultaneously) Author: Eva, I'm gonna, I'm gonna use that description that you just used… Eva: [yelling] I'm in the yellow.
> (Simultaneously) Author: I'm going to ask you to…. Eva: [yelling] I'm in the yellow!
> Eva: I…am...in…the…yellow!
> Author: Yes, I heard you say that.
> Eva: You don't continue if you're in the yellow.

Eva's mother explained that when at school 'in the yellow' means that Eva is upset, and it is a time to bring in tools to help Eva regulate her emotions. Eva was distressed by the corrective feedback and rather than continue with the problem solving she used a self-regulatory strategy she learned in school that helped to lessen her distress.

I also used pressing as a form of feedback to encourage Eva to try a new strategy or consider attributes of shapes. During our second session, when she chose to make a dog with pattern blocks, I pressed her to add a "trapezoid or some more triangles" to the belly to make a bigger dog, to encourage her to see how multiple blocks can be combined to make compound shapes. She rejected the suggestion. I pressed again, and she again rejected it saying, "Not worth it." In another case of pressing her to try to find where a specific shape fit in the puzzle, Eva picked up the puzzle card and dumped the blocks back in their container. Her emotional responses were restrained but she was not motivated to engage with these suggestions.

However, we found Eva responded positively to affirmative feedback which highlighted the mathematics within her activity. This form of feedback was offered most often with the highly graduated, student-centered tasks because this is when she most often engaged in mathematical activity. Eva seemed to find this feedback motivating, evidenced by continued engagement in the activity and future use of the actions or responses which elicited the feedback. With one of the simple 2D shape composition puzzles (see Figure 2, panel B) Eva turned a block to see if it would fit the outline instead of putting the block back in the box when it did not work with her initial orientation. I said, "Wow! What great problem solving! I saw you *turn* the block to find out if it would fit another way." I mimicked turning the block while giving the praise, emphasizing the mathematical idea, vocabulary, and motion. Eva nodded and then continued to work on that puzzle until it was completed, turning most of the blocks before she placed them. She also used that strategy in future puzzles.

I also would include the names of the shapes when giving her affirmative feedback, "Eva, I saw you knew just how many hexagons you needed! How did you know that?" to which Eva replied, "I used my eyes." After several times using the names of blocks, Eva would also try to use the vocabulary when discussing her solutions.

Our interpretation of Eva's responses to corrective and affirmative feedback is that Eva was showing agency and self-regulating her environment. We see this in a number of ways. First, Eva's behaviors were in service of protecting herself emotionally by removing herself from a situation in which she was not experiencing success, something she experiences too often in mathematics classes. Second, we see that Eva's responses to pressing as a rejection of someone else taking over her activity. Finally, we see that in contexts in which Eva felt some success and confidence, Eva maintained her attention to the task and applied the same reasoning in the future.

Discussion

Main Findings

The purpose of this teaching experiment was to identify ways to enhance OTL for a student who had considerable difficulty in mathematics. This is an important aim given the persistent difficulty some students experience, even after receiving supplemental instructional support. We are situated in a perspective on OTL as occurring through the relationship between a student as a unique individual and the learning environment in which they are placed (Gee, 2008). We investigated the relationship between task delivery formats and feedback and how the student evidenced self-regulation. We found Eva's volitional processes were prerequisite to engaging in cognitive processes for mathematical learning. Our findings provide an example of how we can provide supplemental support to better individualize students' learning opportunities.

Regarding the learning environment, and task delivery format and feedback specifically, we found the greatest OTL occurred with highly graduated increases in difficulty and feedback which highlighted the mathematics in Eva's activity. When the lesson was delivered with explicit instruction or cognitively demanding tasks, Eva evidenced inattention, disruptive behaviors, or rejection of the tasks. However, consistent with some previous research on scaffolding (Bruner, 1978; Pool et al., 2013), we found a task structure scaffolded with a gradual increase in difficulty, which allowed for focused attention on a concept, strategy, or reasoning, was supportive for Eva's OTL. Eva engaged with the tasks independently, maintained that engagement, and evidenced increasing confidence and sophistication in her mathematical thinking. Further, feedback in the form of guidance, whether overt direction or less overt pressing, elicited Eva's disengagement with the activity or anger. In contrast, specific, affirmative feedback helped to make Eva aware of the mathematics within her activity and encouraged her to use that activity strategically in subsequent tasks (Freudenthal, 1973).

The importance of this finding is that instruction closely aligned to some visions of high quality instruction were not supportive of Eva's mathematics learning (Cobb & Jackson, 2021; Powell et al., 2022). These findings provide a case when adhering to a single model of instruction did not provide for effective individualization, even though a reliance on explicit instruction is called for when students have difficulty learning mathematics (Grigorenko et al., 2020; Powell & Fuchs, 2015). Therefore, we argue individualizing instruction and optimizing OTL for some learners means intentionally selecting components of instructional models which create a supportive learning environment for the student. For this learner, effective instruction involved a combination of strategies from special education and mathematics education literature, fields which are dominated by divergent perspectives on mathematics instruction and are frequently positioned as incompatible (Advocates for the Science of Math, 2021; Munter et al., 2015).

Regarding the individual in the learning environment, we viewed self-regulation as the way an individual might be attempting to demonstrate agency over their learning experience (De Corte et al., 2000). This perspective was helpful in recognizing a mismatch between Eva's learning needs and the instructional environment, and therefore in evaluating OTL under different instructional conditions (Gee, 2008). Eva did not allow others to take over her thinking. She rejected guidance and sometimes became quite upset when it was pressed upon her. When instructional activities required volitional or cognitive processes she likely found difficult, Eva asserted herself in a number of ways: dancing, singing loudly, and saying that she was "just being myself"; taking over the activity on her own terms; or abandoning the task. This illustrates how one can view off-task, disruptive behaviors or disengagement with tasks as productive for removing oneself from a situation which is distressing or confusing. In contrast, when she was given tasks which she found approachable, and when she could engage without someone else taking over her thinking, Eva engaged and persisted with the tasks.

This finding reveals the benefit of extending our perspectives beyond the view of self-regulation as something to be remediated to help the student adapt to an instructional environment (Kuypers, 2011; Mason & Reid, 2017). We argue that self-regulation viewed as a form of agentic behavior helps to identify the components of instruction that enhance OTL. Specifically, we see this lens on self-regulation offering opportunity for greater understanding of what is needed to individualize learning for those with intensive learning needs. When we consider Eva's expressions of volitional processes such as attention, motivation, and emotions, as agentic, it offers insights into how she might be trying to have some control over her experience within the environment in which she was placed. This can provide us with indicators of when adapting the instructional environment might help the student experience success.

In practice, we can use this perspective to extend beyond offering a general instructional format and training students to express only certain forms of self-regulation in that learning environment. If we take time to consider the instructional context in which behaviors are expressed, we may be able to create opportunities for success and allow the student to build confidence and gradually develop comfort with engaging in learning activities. In this way, we adapt what we offer to the students, rather than ask students to adapt to what we offer. We argue that considering self-regulation in this way is an approach for ensuring students with intensive learning needs are offered individualized instructional support that maximizes their OTL.

Limitations and Future Directions

In research, self-regulation is typically defined as occurring in service of learning (Boekaerts & Cascallar, 2006). Expanding this to consider self-regulation as the way in which children are regulating, or attempting to regulate, their environment opens the door to many lines of investigation. Foremost among these is investigations into the effects of changing features of the instructional environment in response to varying types of self-regulation evidenced by students and measuring learning and self-efficacy outcomes.

This work focused offered the opportunity for in-depth observation and close analysis of one student. We do not make claims that other students with similar individual characteristics will respond in the same way as Eva. We do, however, point out that these results offer a case which counters any universal claims that particular instructional approaches support learning for students. Also, we acknowledge instructional delivery, mathematical content, language processing demands, and the instructor's relationship with the student all interact to affect OTL. However, we are unable to analyze each of these deeply within the space of one article and have written about other features of the environment elsewhere (Crawford & Kernin, 2022; Crawford & Kernin, 2023). Finally, we focus on Eva's responses to the instructional aspects of OTL and make inferences about these based on patterns observed. We only describe our observations and interpretations of the relationship between instructional strategies and Eva's learning; we cannot make any causal claims about the effectiveness of instruction in relation to Eva's diagnoses. We assert that more in-depth analysis of neurodivergent student thinking and learning is warranted and can provide more insights into thinking about individualization and optimizing OTL.

Conclusion

Much research aims to identify optimal forms of instructional delivery for students with difficulty in mathematics by measuring, and sometimes comparing, effects of instructional approaches on learning. As a result, researchers often position a single instructional approach as the vision of high-quality instruction. However, OTL, viewed as harmony between the needs of an individual student and the features of the learning environment, offers a lens which can aid in moving beyond one-size-fits-all thinking. Taking the time to observe a student's self-regulation in mathematics contexts from an asset-based perspective can help to identify ways to improve OTL. From such a perspective, researchers can ask when and why instructional strategies benefit students with difficulty, and practitioners can tailor instruction to meet each student's needs.

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