SUPPORTING INCLUSION OF STUDENTS THAT TYPICALLY STRUGGLE WITH MATHEMATICS IN COGNITIVELY DEMANDING SMALL-GROUP DISCOURSE

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This study examined how two small-group discourse types (Reflective and Exploratory) supported the inclusion and enacted levels of cognitive demand of students who typically struggle with mathematics in real-world, task-based assessment activities. The study focused on 11 fifth-grade students within a larger study involving 97 fifth-grade students engaging with 24 mathematics task-based assessment activities. Results showed that students that typically struggle with mathematics were more likely to participate in group discourse during reflective discourse. Additionally, discourse contributions by these students were more likely to be high cognitive demand during reflective discourse. Reflective discourse provided students with time to think through and write down their own strategies which may have increased student confidence and willingness to engage in explaining and justifying their thinking.

Keywords: Cognition; Classroom Discourse; Elementary School Education; Equity and Diversity

Task-based assessments provide educators with an understanding of students' ability to apply their mathematics understanding to real-world situations. Mathematics discourse can also provide a formative assessment of students' cognitive understandings and misconceptions. Research on mathematics discourse is divided on timing - after (Reflective) or during (Exploratory) student engagement with mathematical tasks –to best support the inclusion of all students' ideas. Thus, the purpose of this study was to examine how these two discourse types supported the inclusion and enacted levels of cognitive demand (CD) for students in four Grade 5 classrooms who typically struggle with mathematics, when engaging with 24 task-based assessment activities.

Theoretical Perspective

Cognitive demand is the number and strength of the connections within and between mental networks, or schema, to solve a specific task (Webb, 1997). High student-enacted levels of cognitive demand (HCD) are defined as students' mental actions that require two or more schema connections to make inferences or connections between mathematical ideas or contexts. HCD can promote deeper student understanding of mathematics properties and procedures, increase students' ability to solve related mathematics problems, and reinforce mathematics connections (Stein, Grover, & Henningsen, 1996). This is especially important for students that typically struggle with mathematics.

Multiple factors can influence student-enacted CD when engaging with mathematics tasks. The Discourse and Interpretation Influences on Cognitive Demand Framework in Figure 1 illustrates a few of these factors. The intended CD, the number of connections anticipated for a student to complete a task (e.g., the designed tasks at specific DOK levels in this study), as well as the implemented CD, teacher actions that encourage different student physical and mental actions (e.g., using recall or reasoning), can influence what and how a task is presented to the students (Webb, 1999; Boston & Smith, 2009). However, research shows that students' interpretation of a task primarily influences their enacted CD (e.g., Otten, 2012). Students may enact multiple elements of HCD or low cognitive demand (LCD) in response to a single task (e.g., using recall of facts to support counter-argument).

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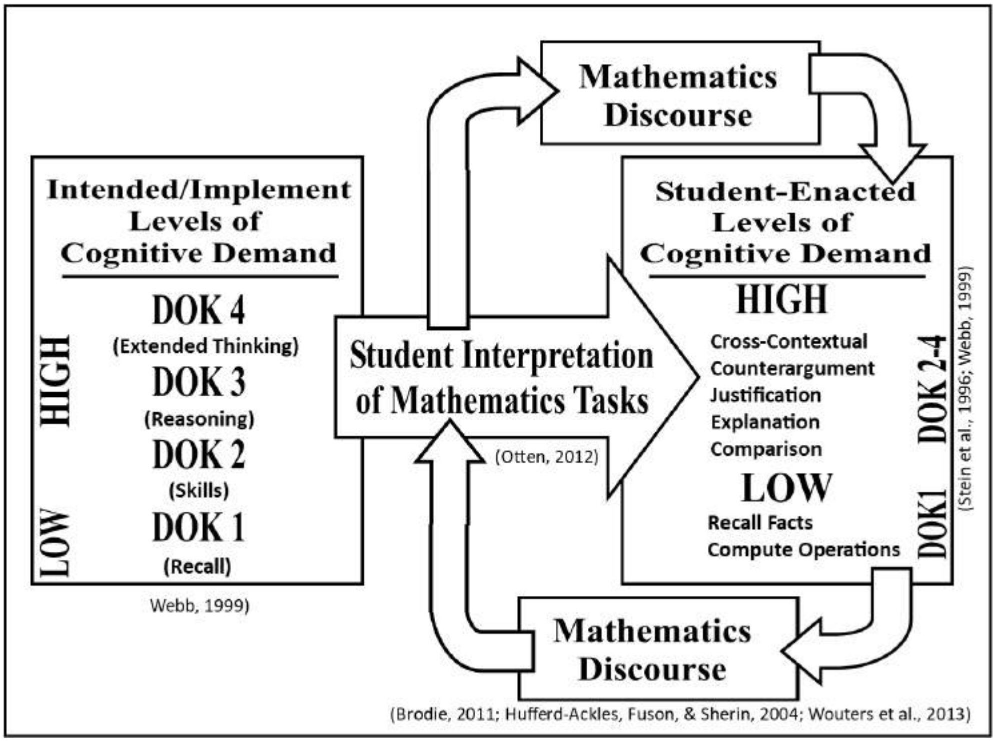

Figure 1. Discourse and Interpretation Influences on Cognitive Demand

As seen in Figure 1, mathematics discourse can influence students' interpretation of mathematics tasks. Mathematics discourse has the potential to increase student-enacted CD by eliciting student participation in HCD actions such as evaluating and reasoning about mathematical properties or procedures (Charalambous & Litke, 2018; NCTM, 2014).

Placement of discourse may also influence verbal and written student-enacted CD. Reflective Discourse takes place after students have engaged with the tasks independently, while Exploratory Discourse takes place while students are engaging with the task. Students' internal discourse and written CD after engaging with Reflective Discourse can influence their verbal contributions towards the social mathematics discourse. Group reflection on differences between verbal contributions, may prompt a change in students' interpretation of the task to develop a more advanced conception of the mathematics task (e.g., Silverman & Thompson, 2008) and may even prompt a change in student-enacted CD. Students' interpretations of mathematics tasks will also influence their verbal contributions towards exploratory discourse as students' personal understandings are negotiated to form a group understanding of the problem (Bruner, 1986; Clements & Battista, 2009; Forman, 2003) and the written CD for the task.

Researchers are conflicted on which placement of discourse is the best. Walter (2018) explains that delaying discourse until students have sufficient time to process the mathematics or write down their own ideas can promote the inclusion of students who might otherwise be ignored, such as typically struggling students. Rojas-Drummond and Mercer (2003) contest that waiting to engage in discourse until after the task is complete results in LCD cumulative talk where students, such as those that struggle with mathematics, simply agree with one dominant idea. Instead, they recommend Exploratory Discourse, which allows students to inclusively discuss relevant information in a timely manner.

Methods

This study utilized a mixed methods research design (Tashakkori & Teddlie, 2010) to answer the research question: How do two types of small group discourse (exploratory and reflective) support the inclusion and enacted levels of cognitive demand (CD) of students that typically struggle with mathematics during real-world tasks?

Participants

This paper focused on 11 of 97 fifth-grade students from a larger study (Litster, 2019). Focus students were identified as typically struggling with mathematics based on self-identification (N=7) during group discourse (e.g., I'm usually wrong/I just don't really get how to do math) or identified with a mathematics IEP (N=4). Six students were identified as English Learners (ELs).

Procedures

Students in four fifth-grade classrooms completed two real-world, task-based assessment activities (12 tasks per set), in groups of two or three. Typically struggling students were in different groups during the study. Students worked collaboratively with a small group on one set, engaging in Exploratory Discourse of solutions and strategies; and individually on a second set, followed by Reflective Discourse of solutions and strategies. Using a crossover design (Shadish, Cook, & Campell, 2002), two classes completed Set-1 with Exploratory Discourse and Set-2 with Reflective Discourse, while the other two classes completed Set-1 with Reflective Discourse and Set-2 with Exploratory Discourse.

Data Sources and Analysis

There were two main data sources in this study: students' written work relating to the mathematics tasks and video/audio recordings of students' interactions and discourse while engaging with the tasks.

The researcher used qualitative magnitude coding to identify and "quantitize" (Saldaña, 2015, p. 86) the enacted levels of CD in students' verbal responses to the mathematics tasks as high cognitive demand (HCD) or low cognitive demand (LCD). Twelve percent of the data were double coded with a relatively high inter-coder reliability (α=0.9212) (Hayes & Krippendorff, 2007). The researcher created frequency tables to compare quantitative results relating to enacted CD. Timestamps from the video data were used to identify time engaged in active mathematics discourse.

The researcher qualitatively coded students' verbal responses using pattern and structural coding to identify patterns in students' actions that seemed to increase or decrease typically struggling students' participation in the small group mathematics discourse

Results

Results found that overall, Reflective Discourse was more likely to support higher levels of cognitive demand in discourse contributions by typically struggling students than Exploratory Discourse. Table 1 shows a comparison of the cognitive demand in student's discourse contributions, based on ability and discourse type.

Table 1: CD of Mathematics Discourse Contributions by Ability and Discourse Type

Mathematics Ability	Reflective Discourse		Exploratory Discourse	
	LCD	HCD	LCD	HCD
Typically Struggling	37.71%	62.29%	50.72%	49.28%
Everyone Else	32.46%	67.54%	29.92%	70.08%

As seen in Table 1, students that typically struggled with mathematics were engaged in HCD discourse for a larger percentage of time during reflective discourse than exploratory discourse. Additionally, there was a smaller difference between ability groups in the percentage of time students engaged in HCD discourse during reflective discourse (5.25%) than exploratory discourse (20.8%).

Reflective Discourse was also more likely to support the inclusion of typically struggling students than Exploratory Discourse. Most groups of students engaged in active mathematics discourse for about 12 minutes per task-set, with an average difference of less than one across the discourse types. However, not every student participated in the discussion for all 12 tasks in each task-set. Table 2 shows the count and average number of tasks where a student remained silent and did not participate in the discussion for an entire task, based on ability and discourse type.

Table 2: Count of Tasks Where a Student Remained Silent

Discourse	Struggling Students (n=11)	Everyone Else (n=86)
Reflective	11 (1.00 per student)	45 (0.52 per student)
Exploratory	57 (5.18 per student)	21 (0.24 per student)

As seen in Table 2, students that typically struggle with mathematics were more likely to remain silent during the discussion of tasks during Exploratory Discourse than during Reflective Discourse. Additionally, there was a larger discrepancy between ability groups in the average number of tasks where a student remained silent for exploratory discourse (5 tasks) than for reflective discourse (<1 task).

Qualitative analyses supported the quantitative results. During Exploratory Discourse, the typically struggling students often said little to nothing during the entire set and were often ignored by their group. For example, the only phrase one student with an IEP, Penny, said while completing a set using Exploratory Discourse was, "You are going too fast." After this comment, her group told her the answers and what to write on her paper after they solved each task. Other struggling students often went without speaking for three or four tasks in a row. Most students who were silent during exploratory discourse appeared to be engaged in active listening (e.g., looking at other students in group and writing on paper in response to other students' comments). However, students who struggled with the mathematics were more likely to disengaged with the tasks completely (e.g., playing with paperclips in their desk).

In contrast, during Reflective Discourse, the typically struggling students were more likely to ask for help. For example, Penny, who talked once during Exploratory Discourse, contributed 19 different times during Reflective Discourse. Most of Penny's contributions confirmed shared answers (e.g., "Yeah, I got that too"); however, occasionally she would ask her group for help or contribute new ideas. An example of this is found in the excerpt below where the group is engaging in reflective discourse after trying tasks 1-3 from Task-Set 1 on their own. In these tasks, students are calculating revenue from movie sales [T1], book sales [T2], and comparisons between the two [T3] for Harry Potter and the Half-Blood Prince.

Wendy: What did you get down here [pointing to T2] cause I didn't finish.
Penny: I am pretty slow writer and thinker so I did not make it down there. But show me what you did.
Wendy: I did .5 million times 12.99. [points to work for 500,000 times 12.99 that is half finished]
Penny: It says round. $12.99 is like $13 so can you just do 13 times 5?
Xander: So I did that and I got 65.

Wendy: So on this one [points to T3], I am pretty sure this is the movie [points to T1] and this is the books [points to T2]
Penny: Paperbacks means books
Wendy: So yea, so up here [T1] is 247.24 million and the highest one here [T2] was just 65 million so I think down here people saw the movie more.
Penny: Yea, I think they saw the movie more. That's [pointing to 247.24 on her page] way bigger than that [pointing to 65 on Xander's paper].
Xander: The price [on the books] was bigger than $7 [price of movie ticket] and the price was bigger but it is a smaller number [total book revenue].
Penny: Yea and I think people don't really like reading any more.
[Video 210H1, 0:31-2:35]

In this excerpt, we can see that, not only is Penny asking for help, her group is willing to explain their answers rather than just asking her to copy them. Additionally, Penny was able to add ideas and strategies to the discussion, such as rounding 12.99 to 13 for an easier computation problem, a comparison to justify an agreement, and a possible context for the lower book revenue. Although no one in the group caught the mathematical error for multiplying 13 x 5 instead of 13 x .5, there was evidence of high verbal CD by all three students: Penny's counterexample for rounding $12.99 to $13, Wendy's justification of why people saw the movie more, and Xander's comparison of the inverse relationship between T1 and T2.

One factor that may help explain the increased discourse and HCD contributions by typically struggling students is that groups engaged in reflective discourse often had one student (not typically struggling) who started the discussion by asking about a task they struggled with. For example, in this excerpt Wendy moved the discussion directly to Task 2 because she struggled to complete her very large (and unnecessary, though mathematically accurate) calculation. Seeing other students struggle may have helped students who typically struggle feel more comfortable asking for help or offering ideas. It also may have helped the other students in the group feel more patient with their explanations because they could point to their work during their explanation or compare their work to the struggling student's work to find where their calculations diverged.

Qualitative analyses also noted a pattern in validation of student ideas. During exploratory discourse, struggling students' ideas were often devalued by other members of their group. However, this was not the case during Reflective Discourse. The following excerpts from the group working with Miguel, a Latino EL student with a Math IEP, provide examples of this behavioral pattern. In this first excerpt, Miguel, Tara, and Ryan are engaging in exploratory discourse to solve task 5 in Task-Set 1. In this task, students are comparing different sources of online movie ratings for Harry Potter and the Half-Blood Prince.

Ryan: So Amazon is 3 3/4, minus iTunes, which is 4.
[Ryan and Tara start to subtract the fractions]
Miguel: It's 1/4
Tara: You have to show your work
Miguel: I just know it
Tara: Then how did you do it in your head? Cause you can't minus that. That would equal 1 ¾ so how did you do that in your head?
Miguel: It's just like . . . [pointing to line plot] .
Tara: [interrupting] If you can't say it then you need to do it.
Miguel: Maybe if you do 4 minus 3 and you get 1 . . . and then minus ¾
Tara: You can't do that or you would get negative. You have to change this to improper fraction and that makes 4/1 and this [points to 3 ¾] makes 9/4 and you have to make a common denominator

so this is 16/4 and then you subtract so it's 7/4 and then you have to change it to a mixed number so the answer is 1 ¾.
Miguel: Yours is probably correct.
[Video 460H2, 11:30-13:20]

In this excerpt, we can see that even though Miguel had the correct answer and what appeared to be a valid strategy to get to the answer, Tara's interruption did not give him the time to fully work out his reasoning to support his answer. In the end, Miguel conceded that Tara was probably correct, even though her calculations were incorrect. This pattern of concession was similar among other typically struggling students whose divergent answers or strategies were not valued or explored (e.g., "Okay, you're the smart one, so what's the answer;" or "You are probably right cause you are usually right.").

In this second excerpt, Miguel, Tara, and Ryan each completed Tasks 6-10 in Task-Set 2 on their own and came together during Reflective Discourse to discuss their answers and strategies. In these tasks, students are calculating and comparing production and retail costs for the Diary of a Wimpy Kid book series. In the excerpt from Task 7 below, they are discussing their calculations for possible fractional discounts [e.g. ½] off the rounded retail price [$60].

Tara: So on this one I multiplied and ½ times 60 is 30.
Miguel: I divided.
Tara: No, so you have to multiply. You change this to an improper fraction so 60 is on top of 1 and then 60 times 1 is 60 and . . .
Miguel: [interrupts] But it's the same answer [points to paper].
Ryan: Me too. So 1/3 of 60 is like 20.
Tara: Yep and 1/4 times 60 is 40.
Miguel: It's 15. Cause 40 + 40 + 40 + 40 is more than 60.
Ryan: So 1/5 of 60 is 12.
Miguel: And 60 divided by 10 is 6.
Tara: So 1/7 times 60 is . . . 49?
Miguel: [Shows Tara his division] so it rounds to 8.
Tara: Ok [revises her answer]
[Video 460D2, 2:51-3:54]

In this excerpt, Miguel had a chance to try out his strategies before comparing answers with Ryan and Tara, which may explain why he appears more confident in his answers and in his strategies than he was in the exploratory excerpt. During Reflective Discourse, Miguel was able to show Tara that his strategy produced the same answer as hers on the first few calculations. This may have helped Tara to accept his strategies and answers on the later calculations that did not match her answers. One reason Reflective Discourse was more likely to support the inclusion of typically struggling students may be that it provided students time to think through their own strategies. Miguel was able to conceptualize a unit-fraction discount as a whole number division problem, a strategy that was only used by one other person in the entire study.

One exception to these patterns was Summer, a Native American EL student with an IEP. Summer's group was very patient with her and never took over her work. For example, if Summer said, "I need help," her group would ask, "Which part," or "Would you like to try . . . [specific strategy from class]." Additionally, Summer's group would use questioning techniques such as "Do you remember how [teacher's name] taught us last week?" or "Okay, so what do you need next to be able to do that?" at least three times before offering a specific suggestion for the next step. During both exploratory discourse and reflective discourse, Summer's group waited to continue until Summer was confident in her work. Group support and validation may have provided Summer with the support to ask questions, request more time to complete a task, and offer the occasional strategy to complete a task, regardless of discourse type.

Conclusions

In conclusion, both discourse types elicited HCD discussions such as evaluating and reasoning about mathematical properties or procedures, similar to other research results (e.g., Charalambous & Litke, 2018; NCTM, 2014). However, Reflective Discourse practices were more likely to support the inclusion and HCD discourse contributions of students that typically struggle with mathematics, during the real-world tasks in this study. These results are similar to other research on reflective discourse practices such as Kalamar (2018) who found that by the end of her three-week intervention, 100% of minority and typically struggling students in an intervention class were participating during Reflective Discourse.

Similar to Walter's (2018) findings, wait time may play an important role in increased participation of typically struggling students. Reflective discourse practices allow students time to think through and try out their strategies prior to the discussion. Having a clear train of thought, as well as a tangible artifact to refer to, may have increased student confidence and willingness to participate in the discussion. In this study, students who do not typically struggle with mathematics were more likely to admit when they were struggling with a problem or answer during reflective discourse than during exploratory discourse. This may have also contributed to an environment where the typically struggling students were more willing to ask questions or propose their own ideas.

Finally, the results relating to Summer and her group bring forward the need for future studies relating to group norms, such as those used by Summer's small group, that may support the inclusion of students who are traditionally excluded from small group discourse, regardless of discourse type.

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