Novice College Mathematics Instructor Communication About Cognitive Demand

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Many incoming graduate students become novice instructors with little to no experience teaching at the college level. Such novices may take part in professional learning opportunities from general workshops on teaching to specific work to prepare for teaching with a particular curriculum (e.g., course coordination). One aspect of preparing to teach is developing skill in supporting students to "successfully engage with a mathematical task" (Stein et al., 2009). To do so, novice instructors must consider the context of the student learning experience as well as the level of cognitive demand for the mathematical task (Smith & Stein, 1998). A curriculum may have a wealth of mathematical tasks available to assign to students, requiring varying levels of cognitive demand (e.g., recalling and applying memorized facts, using procedures with and without connection to other knowledge, and the most cognitively demanding work of doing mathematics in a novel situation). Though research exists on cognitive demand and the preparation of teachers to attend to it for K-12 mathematics, little research has focused on the needs of novice college mathematics instructors. In this poster, the focus is on addressing the research question: How are novice instructors' instructional decisions informed and shaped by consideration of cognitive demand?

Previous research on cognitive demand in the preparation of novice instructors focused on how they interpreted and transformed the definitions of "cognitive demand" and "scaffolding" of student learning (Milbourne, 2018). The poster builds on this, focusing on how novice instructors make sense of and communicate with colleagues about cognitive demand in the context of a weekly teaching workshop. The data collected included nine novice instructors' responses within asynchronous online activities and live audio and video of three consecutive workshop discussions about cognitive demand in various college mathematics classroom examples (e.g., video case materials, Hauk et al., 2013). The inductive qualitative analysis uses van de Pol's (2010) framework for scaffolding, involving contingency, fading, and transfer of responsibility. Initial analysis indicates novice instructors described various "benefits" from lowering cognitive demand that expand on the collection reported by Milbourne. As in previous work, novices talked about "getting through more material". New "benefits" voiced by novices in this study included improving student confidence and self-efficacy. The new findings are related to consideration of the student's perspective.

The goal at the poster is to engage RUME conference participants in discussing novice instructor decisions on how to set cognitive demand goals and why they might set those goals. Poster-side conversation can inform the ultimate reporting of study findings. Results of the research can be used in (re)development of professional learning opportunities offered to novice college mathematics instructors and can shape future research on how novices improve their instructional skills in task-level decision-making.

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Poster Purpose: To collect ideas while discussing novice instructor decisions on how to set cognitive demand goals and why they might set those goals.

Context

Project Objective:

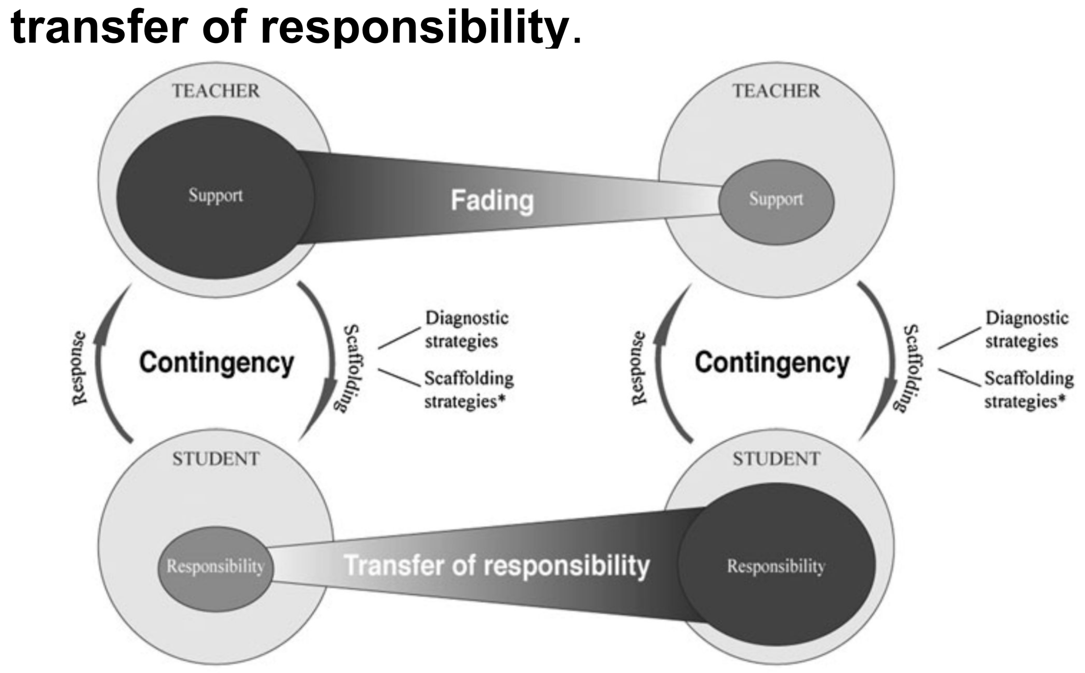
Understanding how are novice instructors' instructional decisions informed and shaped by consideration of cognitive demand.

Background:

Many incoming graduate students become novice instructors with little to no experience teaching at the college level. Such novices may take part in professional learning opportunities from general workshops on teaching to specific work to prepare for teaching with a particular curriculum (e.g., course coordination). One aspect of preparing to teach is developing skill in supporting students in successfully engaging with mathematical tasks. To do so, novice instructors must consider the context of the student learning experience as well as the level of cognitive demand for the mathematical task (Smith & Stein, 1998). Though research exists on cognitive demand and the preparation of teachers to attend to it for K-12 mathematics, little research has focused on the needs of novice college mathematics instructors.

Framework:

This project uses van de Pol's (2010) framework for scaffolding student learning. The characteristics of scaffolding included **contingency**, **fading** and **transfer of responsibility**.



Conceptual Model of Scaffolding from van de Pol (2010)

Research Questions

1) In the context of a particular classroom activity and associated assessment, what is the nature of GTA communication about and use of cognitive demand?
2) How are curriculum and assessment decisions for scaffolding student learning informed/shaped by GTA consideration of cognitive demand?

Mini-Course Embedded within a Teaching Workshop

Setting: Nine graduate students pursuing masters' in mathematics enrolled in a 3-credit Graduate Teaching Workshop. Each was a new graduate teaching associate (GTA) – instructor of record for undergraduate math courses for the first time. A 2-week section of the workshop was dedicated to noticing and responding to cognitive demand.

Asynchronous Activities:
GTAs did a mini-lesson that was organized as exploration, discussion boards, and self-quiz in classifying cognitive demand.

Synchronous Class:
Included small and whole group discussion of portions of the mini-course and readings related to student group work and classroom management techniques.

Levels of Cognitive Demand

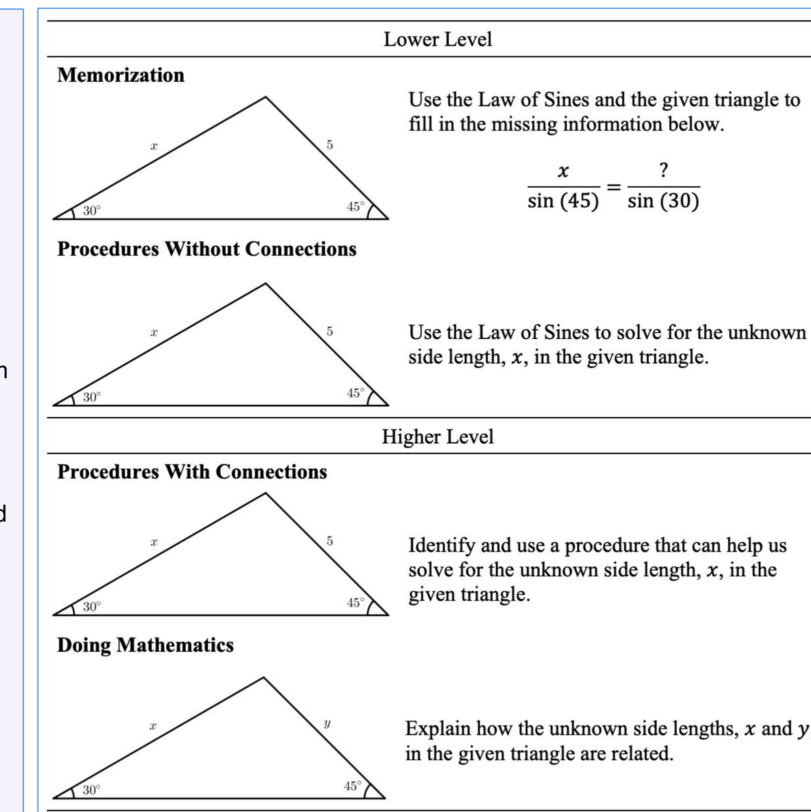
Lower-level demands *(memorization)*
- Involve either reproducing previously learned facts, rules, formulas, or definitions or committing facts, rules formulas or definitions to memory
- Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure
- Are not ambiguous. Such tasks involve the exact reproduction of previously seen material, and what is to be reproduced is clearly and directly stated

Lower-level demands *(procedures without connections)*
- Are algorithmic. Use of the procedure either is specifically called for or is evident from prior instruction, experience, or placement of the task.
- Little ambiguity exists about what needs to be done and how to do it.
- Have no connection to the concepts or meaning that underlie procedures being used
- Are focused on producing correct answers instead of developing understanding
- Require no explanations or explanations only describing the procedure that was used

Higher-level demands *(procedures with connections)*
- Focus student's attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas
- Suggest explicitly or implicitly pathways to follow that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts
- Usually are represented in multiple ways, such as visual diagrams, manipulatives, symbols, and problem situations.
- Although general procedures may be followed, they cannot be followed mindlessly

Higher-level demands *(doing mathematics)*
- Require complex and nonalgorithmic thinking – no predictable, well-rehearsed approach or pathway is explicitly suggested by the task, task instructions, or a worked-out example.
- Require students to explore and understand the nature of mathematical concepts, processes, or relationships
- Demand self-monitoring or self-regulation of one's own cognitive processes
- Require students to access relevant knowledge and experiences and make appropriate use of them in working through the task
- Required students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions
- Require considerable cognitive effort and may involve some level of anxiety for the student because of the unpredictable nature of the solution process required

Based on Smith and Stein (1998)

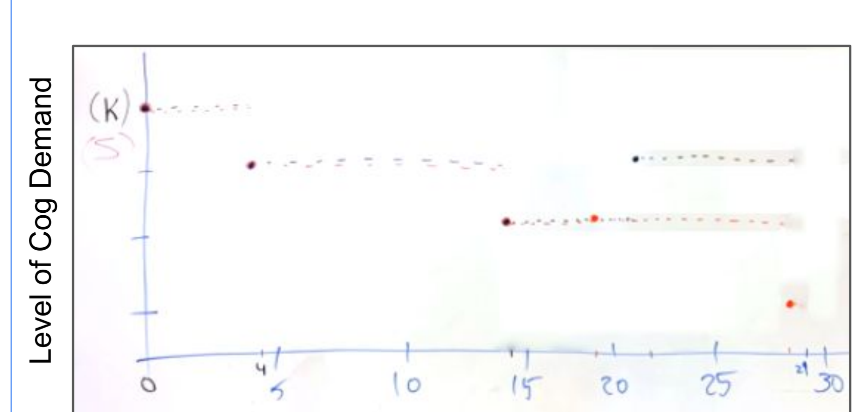


Data Collection:
Audio and video was recorded over three consecutive days during the synchronous workshop (~30 min recording each period). Participants completed portions of the asynchronous work in the previous week and some concurrently.

Results

Tracking Cognitive Demand

Given a conversation among Kristen, Brad, and Ted, (video & 29 lines of transcript), plot the cognitive demand across time/lines of transcript. GTAs agreed the interaction started at 4 (Doing Math) and ended at 1 (Memorization). But plots differed.



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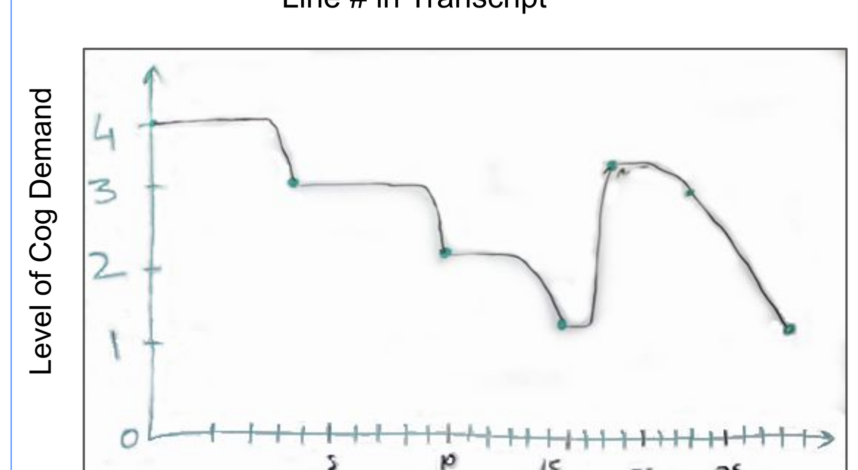

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Later, individual GTAs described their decision-making. That communication highlighted their sense-making in trying to understand "level" of cognitive demand.

Changes in Cognitive Demand

I also think in the parts when the **cognitive demand <u>keeps constant</u>** it is because the question the instructor was proposing **gave the student the opportunity to continue thinking** and using their knowledge to try to solve the problem.

She does say "cancel" and it is **telling a student exactly what to do.** That is the exact point where the **<u>cognitive demand drops</u>**.

Brad answered by memory (he knows the rule). Then … the **<u>[cognitive demand] level increased</u>** because Ted found that it doesn't match up, they found a problem and **now they need to make some connections** to solve it.

Emerging Awareness of Cognitive Demand

"I was thinking that each of those is sort of mapped to one assignment like, one assignment is the level of doing math, or one assignment is the level of memorization. But then … **two students could look at the same problem** and be at **<u>different levels</u>** <u>[</u>of cognitive demand]. "

Personally, I believe that the learning shift should be continuous and that **there exist <u>sub-levels in between</u> the 4 main cognitive demand levels** that were indicated because even in those 4 basic levels, there are already some **overlapping characteristics.**

Discussion

GTAs described various "benefits" from lowering cognitive demand that expand on the collection reported by Milbourne. New "benefits" voiced by novices in this study included **improving student confidence and self-efficacy**. The new findings are related to **consideration of the student's perspective**.

GTAs described practices that they thought would maintain cognitive demand of *Procedures With Connections.* Some would, some might not:

GTA suggestion	*# of GTAs*	*Likely Cognitive Demand Result*
<u>Ask the student:</u> *What do we know about sides and angles?*	4	**Maintain** cognitive demand
<u>Direct the student:</u> *Think about concepts related to trigonometry.*	2	**Reduce** cognitive demand
<u>Redirect the student:</u> *Look at your notes and see what might be a useful procedure.*	1	**Maintain** cognitive demand

Posterside Conversation

- How might novice instructors set cognitive demand goals?
- Why would the particular cognitive demand goal be set by a novice instructor?
- How and why might the goals set by novice instructors about cognitive demand differ from experienced instructors?
- Other questions? Comments?

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