THE ROLE OF A BOUNDARY OBJECT IN A STUDY OF MIDDLE GRADES MATHEMATICS INSTRUCTION

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This report is about how a group of U.S. teachers (N =98) and researchers used a boundary object in a collective study of grades 6-8 mathematics instruction. The focus is the teachers' engagement with a framework for effective instructional practices. Using qualitative content analysis of teachers' responses to use of the framework, we assessed its implementability and usefulness while supporting shared understandings of effective mathematics instruction. We found the framework supported shared understanding and implementation across varied contexts and was viewed as useful for meeting teachers' instructional and professional goals. Constraints were related to ambiguity around understanding and use of instructional practices related to student struggle. These findings demonstrate how a brief researcher-designed framework can serve as a bridge between teachers and researchers, meeting the professional goals of both.

Keywords: Middle School Education, Professional Development, Instructional Activities and Practices.

Our research is set in U.S. public middle schools, places where dissonance is a daily part of life (especially in band classrooms). In mathematics classrooms, students and teachers need to blend their often wildly different interests and goals to make the shared time together meaningful and mutually enriching. Nurturing harmony in these classrooms can be challenging, but it is a necessary condition for thriving mathematics education. Meanwhile, as researchers of effective mathematics instruction in the middle grades, we face an additional layer of dissonance. We come from a research culture and aim to build transferable knowledge of "what works", while our collaborating teachers are mostly focused on tuning their individual classroom practice to meet the needs of their students and schools. This study is about one way we have tried to orchestrate harmony in that context.

We are conducting a large-scale grant-funded study of sequences of mathematics instructional strategies within a teacher-researcher partnership (Kieran et al., 2012; Koichu & Pinto, 2018). Our project hinges on a guiding framework that effectively supports shared understandings, implementability, and motivation. While we aim to help teachers understand and use the framework, we take an explicitly asset-based approach to the work. As researchers, we know about effective instruction as described in the literature, and our collaborating teachers know about effectively working with students in their contexts. These ways of knowing about mathematics instruction introduce a "boundary" (Wenger, 1998), a useful analytic concept for studying teacher-researcher partnerships because it reflects the dissonances in our perspectives and goals while describing how learning may take place across the boundary (Akkerman & Bakker, 2011). The tool that has served as a boundary object (Star, 2010) for bridging our ways of knowing about mathematics instruction is a framework.

Theoretical Framework

EAC/SOS framework

We see our framework as the centerpiece of our work to learn alongside teachers about what works in their contexts. Based on decades of research addressing effective mathematics instruction, the Explicit Attention to Concepts (EAC) and Students Opportunity to Struggle (SOS) constructs were described by Hiebert and Grouws (2007) as primary clusters of instructional practices with robust evidence for supporting students' conceptual understanding of mathematics. Stein et al. (2017) subsequently operationalized the constructs, finding further evidence of the practices for supporting high student achievement on assessments of both procedural and conceptual knowledge in mathematics.

We developed a two-page practice guide for teachers to support the enactment of EAC and SOS in their classrooms (see Figure 1; Champion et al., 2020). The artifact presents three *features* for each construct. The features that characterize EAC instruction are (a) a focus on concepts, (b) making concepts explicit and public, and (c) emphasizing connections. The features that characterize SOS instruction are (a) a focus on sense-making, (b) application of sustained mental effort, and (c) engagement with important mathematics. The *constructs* and *features* are meant to broadly describe effective practice, but the guide also includes examples at a finer grain size. Each construct lists four instructional *strategies* with two accompanying *routines*, which more explicitly detail what enactment could look like in the classroom. Lastly, each strategy is annotated with potential instructional *tools* that teachers could use to support the enactment.

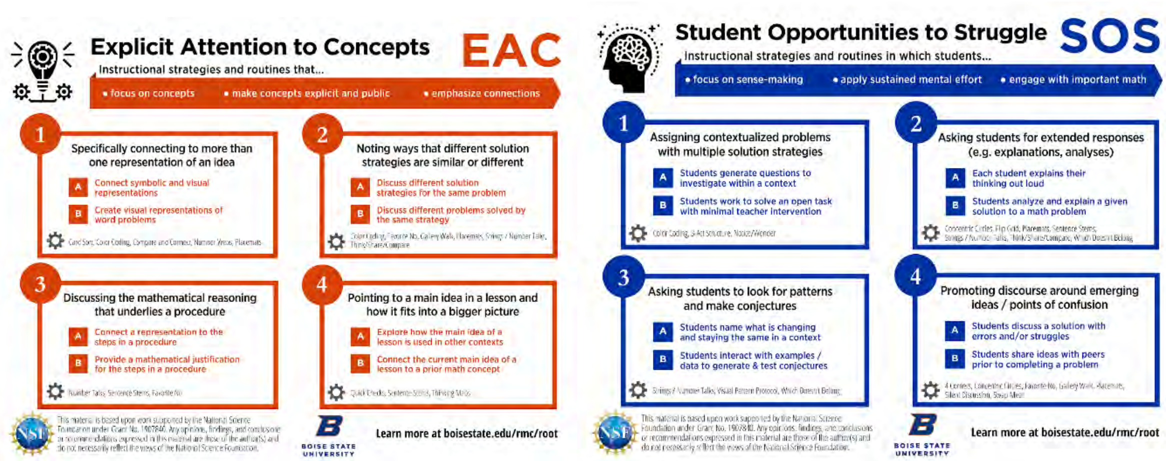

Figure 1: EAC/SOS Guide to Instructional Practices for Improving Math Achievement

EAC/SOS Framework as a Boundary Object

Our project is a boundary encounter between two communities of practice, mathematics education researchers and teachers, who are working toward a common goal of building useful knowledge for both communities (Wenger, 1998). Within boundary encounters, boundary objects are "things" (either physical or conceptual) that act as a bridge between communities (Star, 2010). As a bridge, a boundary object should be accessible to multiple perspectives, allowing shared meanings to be negotiated (Akkerman & Bakker, 2011; Star, 2010). In an investigation of a boundary object in teacher professional development, Edgington et al. (2016) found their framework was used by teachers in both expected and unexpected ways, suggesting opportunities for researcher learning through investigations of teachers' meanings around the boundary object. As researchers, our goal was to communicate research at a boundary while valuing collaborating teachers' expertise, so we identified teachers' interpretations of the boundary object as pivotal. Our guiding research question was, "To what extent does the EAC/SOS framework function well as a boundary object with middle school mathematics teachers, supporting shared understandings of effective mathematics instruction while being adaptable in teachers' diverse contexts?"

Method

Our study centers collaborating teachers' perspectives of the EAC/SOS framework. We used qualitative content analysis, which involves interpreting meaning from text, to understand teachers' feedback on their engagement with the framework across the first year of our partnership.

Participants

The participants in this study are Grades 6-8 mathematics teachers from 34 schools within 22 school districts in the western United States ($N = 98$). All teachers were working in public schools. Nearly all worked in brick-and-mortar schools, though one teacher worked for a virtual public charter school. Teachers' mathematics instruction often spanned multiple grades (49 taught Grade 6, 44 taught Grade 7, and 44 taught Grade 8) and courses (37 taught one course, 48 taught two courses, and 12 taught three or more courses). The teachers worked in a variety of school settings, both in terms of students' socio-economic status (mean eligibility for federal free or reduced school lunch was 58%, $SD = 21\%$) and locale type (31% rural, 69% suburban or small city). Teacher demographics indicated substantial variability in mathematics teaching experience (mean = 9.8 years, $SD = 7.4$, Range = 1 to 32), and they primarily self-identified as female (77%) and white (96%). Teachers' highest academic degree was typically a bachelor's degree (57%), though 40% held a master's degree, and 2% held an Ed.S.

EAC/SOS Guide & Professional Development Modules

The framework was enacted by inviting teachers to engage with the two-page guide and three supporting professional development modules. The first two modules were in-person and synchronous and, due to the COVID-19 pandemic, a third module was online and asynchronous. The focus of Module 1 was an orientation to the research project and the EAC/SOS framework. Modules 2 and 3 focused more deeply on EAC and SOS strategies, respectively. The in-person meetings gathered all teachers together for 4 hours on Saturday mornings. The asynchronous modules integrated online tools in the form of virtual bulletin boards, an interactive mathematics activity builder, and a video-based interaction platform.

Data Sources

We used extant data that was collected across the first year of the project to inform decisions about upcoming modules or engage teachers in exploring ideas (Table 1). These data were collected via graphic organizers and online forms. Questions asked of teachers varied each time, depending upon what information was desired to inform upcoming professional development sessions.

Data Analysis

We applied a three-level analysis (Simon, 2019). At the first level, we worked with the teachers' responses as raw data. We tabulated frequency counts for strategy and routine choices and coded textual data, guided by the research purpose and using constant comparison (Corbin & Strauss, 2008). To verify the trustworthiness of our coding at this level of analysis, we checked the comparability of coding within Data Source 3 (DS3, see Table 1). Two researchers applied open coding to half of the responses, and the team then discussed the codes and established a coding dictionary. To check for reliability of coding, two researchers used the coding dictionary and coded data in DS5. We compared the frequency with which codes were applied to responses; average exact agreement across codes was 68% and within 2 agreement was 91%. Disagreements were reconciled, and definitions were refined. Using this refined coding scheme, a single researcher conducted the remaining analyses and summarized each data source. These summaries described the context of the data (what the teachers were responding to and why), provided tables with frequencies of applied codes, and exemplar responses for frequent codes.

The second level of analysis identified themes across the summaries with reference to the original data as needed. Two researchers engaged in this process independently, and the full research team then compared the themes, discussing similarities and differences. A third researcher then compiled the results of the discussion into a final set of claims related to the research purpose. In the third level of analysis, we applied abductive reasoning to the second level claims to identify inferences which, if true, would account for the data (Simon, 2019). The goal is to consider the claims with the intention of contributing useful postulations that apply beyond the scope of this particular study. These inferences therefore inform our understanding of the success of the framework as a boundary object in a teacher-research partnership.

Table 1: Summary of Data Sources

Data Source ID	Module	Data Source	Content	# of Responses
DS1	1	Comfort-Frequency Notes	Compare comfort-frequency of strategy implementation to a peer	85
DS2	1	Implementation Cycle 1 Plans	Choose a strategy to try out in classroom and explain why it was chosen	94
DS3	1	Implementation Cycle 1 Reflection	Indicate what strategy was tried and what went well and what was difficult.	98
DS4	2	Implementation Cycle 2 Plans	Choose an EAC strategy to try out in classroom and explain why it was chosen	94
DS5	2	Implementation Cycle 2 Reflection	Indicate what EAC strategy was tried and reflect on how it went	93
DS6	3	SOS Impressions	Read a description of SOS, comment on using SOS in classrooms	89
DS7	3	SOS Strategy Identification	Watch a video, identify strategies and teacher moves to support struggle	97
DS8	3	Implementation Cycle 3 Plans	Choose and SOS strategy to try out in classroom and explain why it was chosen	83

Findings

This study investigated teachers' responses to determine the extent to which the framework supports a shared understanding of research-supported instructional practices and the extent to which teachers view the framework as implementable and useful.

Understandings about EAC and SOS

We looked for evidence of teachers' understandings of the framework across their reasons for selecting strategies. These data sources were coded for degree of alignment with our understandings as researchers. Coding categories were: aligned (described key features of the construct), partially aligned (described strategy without language related to key features), unaligned (confused the constructs or added unintended ideas), or unclear (e.g., "it fits my curriculum"). Figure 2 shows the respective percentage of responses in each category across the three modules. The majority of responses, 70% and above, were aligned or partially aligned. We believe this degree of alignment early in our project indicates success of the framework for supporting shared understandings. However, we note that the degree to which shared understandings were established was stronger for EAC than SOS. This discrepancy is also evident from DS7 in which we asked teachers to watch and respond to videos of a teacher implementing SOS strategies, from which only 39% of responses were coded as aligned, while 59% of responses were coded as partially aligned.

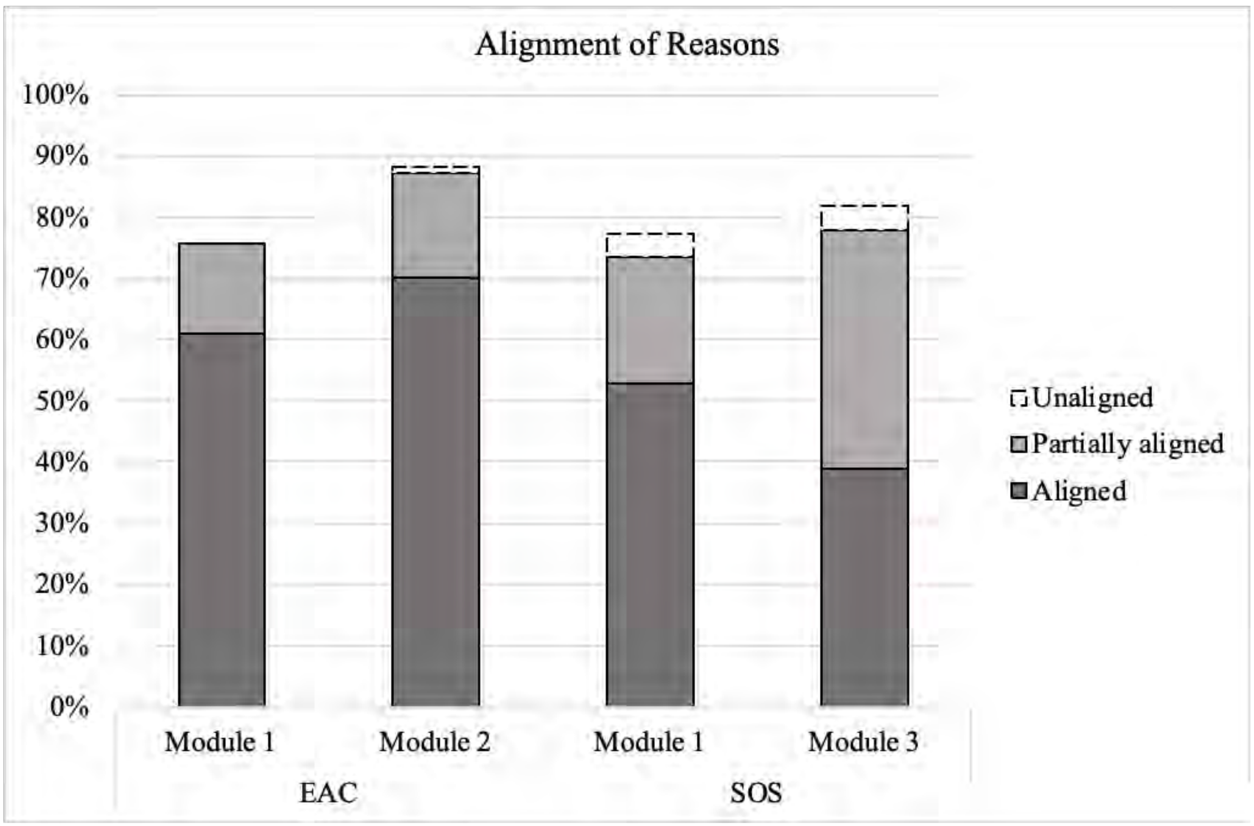

Figure 2: Alignment of Reasons for Strategy Choice to Researchers' Intended Meanings

Teaching Context

We wanted to determine to what extent the framework was viewed by teachers as implementable in their contexts. We found the framework offered options that were taken up by teachers across these contexts, and we found teachers preferred different strategies based on their experience, interests, and school or district context. Teachers' reasons for selecting strategies (Figure 3) indicated contextual factors such as the needs of their students, aligning with curriculum or learning goals, and teachers' experience or interests. When we asked teachers to rate EAC and SOS based on their comfort and frequency of use, and then comment on similarities and differences to the ratings of another teacher (DS1), 62% of comments related specifically to choices based on teaching context, including curriculum, working environment, years of experience, and teachers' individual personalities.

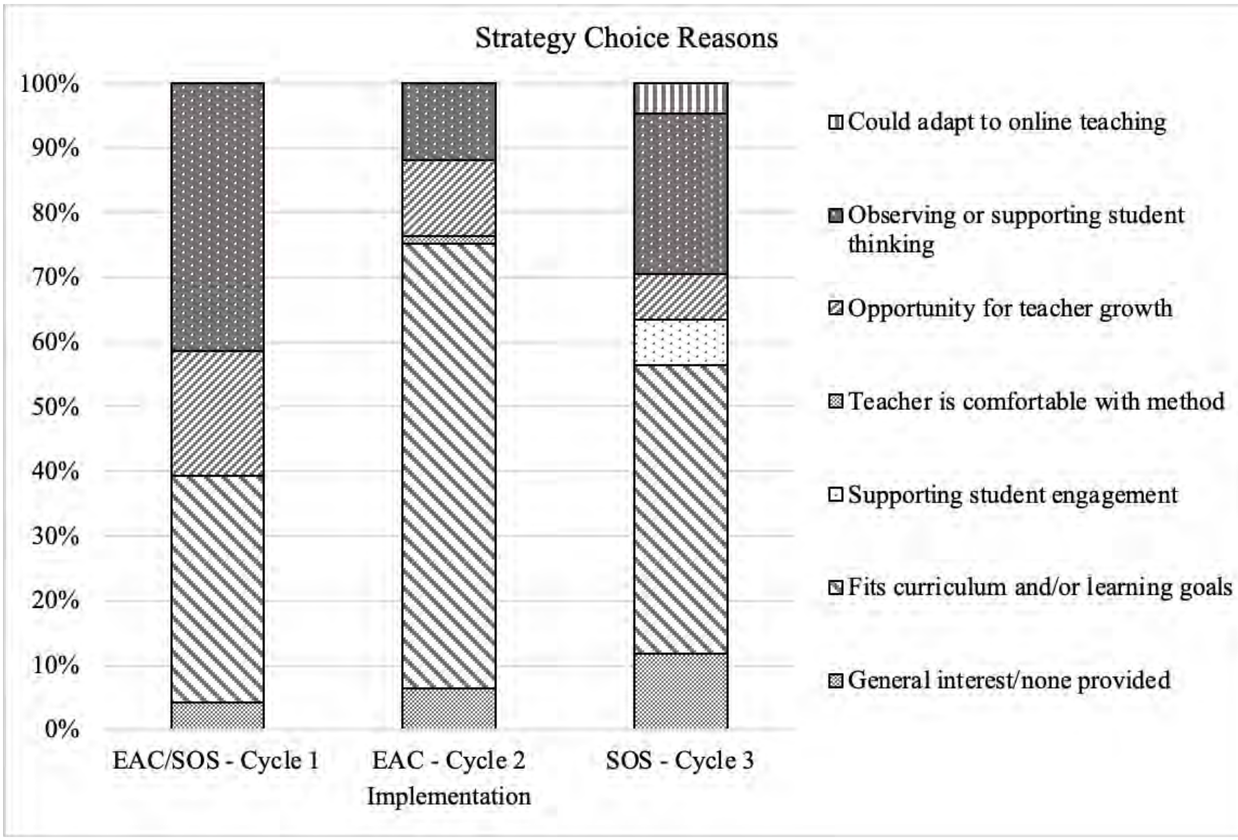

Figure 3: Themes Identified in Reasons for Strategy Choice

Despite evidence that teachers identified adaptable options in the framework, some data indicated a perception that SOS may not be successful with some students. After implementation cycle 1 (DS3), teachers reflected on the benefits and challenges of the experience. The primary difficulty related to SOS was "student engagement" which accounted for 61% of the SOS responses. A response that suggests SOS may not be successful with some students was, "It was very difficult to engage the students who struggle in math….A lot of scaffolding and accommodating was needed." Also, DS6 asked teachers to comment on a reading about the meaning of productive struggle, and 22% of the comments focused on the challenge of using SOS with some students. A characteristic response was, "With productive struggle it never really feels like they are learning anything, especially without teachers teaching step by step. Students definitely give up when they don't understand something, so how can they productively struggle if they keep giving up?"

Opportunities for Teacher and Student Learning

In support of implementation, we hoped teachers would interpret the framework as useful and motivating for innovating their professional practice. We found teachers described its usefulness in terms of offering opportunities for teacher and student learning. We identified the theme of opportunity for learning as reasons for selecting a strategy across all three cycles of implementation (see Figure 3). An example of a response that fell under this theme is a teacher's explanation for choosing an SOS strategy, "I believe that I guide my students too much to the answer, and give them too much information, which gives away the Ah Ha moments. I want to work on allowing the students to explore more of the problem without just giving them their answers" (DS2). In addition to identifying this theme in reasons for strategy choices, we identified this theme in 20% of teachers' reflections on implementation cycle 1 (DS3) and 17% during cycle 2 (DS5).

A number of teachers interpreted the strategies as opportunities to facilitate learning by focusing on student thinking. As seen in Figure 3, we identified the theme of "observing or supporting student thinking" in 41% of reasons for selecting a strategy in the first implementation cycle, 11% in the second, and 25% in the third. An example of a response that supports this claim is related to the SOS strategy of promoting discourse among students around emerging ideas, "Want to see if it will help with further understanding the concepts amongst the kids" (DS8). We also identified this theme in teachers' reflections. "Students learned" and "students were engaged" accounted for 88% of the descriptions of what went well after implementation cycle 1 (DS3) and 37% after implementation cycle 2 (DS5).

Discussion

This study aimed to understand the EAC/SOS framework as a boundary object bridging two communities of practice. We believe that this investigation of the boundary object can offer guidance to others involved in similar projects that involve communicating across such boundaries. We found the framework, by and large, supported shared understandings. We also found that teachers could identify appealing options and meaningful benefits from the framework, indicating they viewed it as implementable and useful. Despite the indications of shared understandings and positive reception of the framework, there are some challenges around the meaning and implementability of SOS. One potential contributing factor for this is the possibility that teachers who are accustomed to 'traditional' mathematics instruction may find EAC more accessible than the more student-centered 'reform-oriented' instruction associated with SOS. Researchers working with teachers to study SOS may need to provide additional experiences and resources for implementation. Teachers' context may be important, as well as teachers' beliefs about their students' abilities to learn through productive struggle.

Implications

Based on our findings, we offer some provisional recommendations for teacher-researcher partnerships to study mathematics instruction:

- Expect some aspects of the research lens you are using to be easily understood and translated by practitioners, while it may be more difficult to form shared understanding around others.
- Use cycles of data collection to monitor teachers' perceptions and implementation results, and adjust the planned meetings between each cycle.
- Give teachers an overview of the theory and research underpinning the project, and then ask teachers what information they need to translate this to their practice (e.g., video examples, curricular materials, rehearsals).
- Be mindful of teachers' context and beliefs. Provide multiple entry points, choices for teachers with different contexts, and be aware the assumptions and expectations of teachers may or may not align to those of the researchers.

Conclusion

To achieve harmony between our goals for learning "what works" in a broad sense and teachers' goals of fine-tuning their individual classroom practice, we investigated the EAC/SOS framework as a boundary object. We centered teachers' voices and found evidence in their responses that the framework supported shared understandings, strong implementability, and the usefulness of the framework across varying teaching contexts. These affordances are signs that the framework provides entry points for engaging teachers in professional learning around these constructs. However, we also found constraints of the framework, particularly around SOS. The constraints indicate specific ways to better support teachers' understanding and implementation of SOS, and the study findings indicate several ways to scaffold teacher-researcher partnerships in order to build meaningful knowledge of effective mathematics instruction.

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