ARTICULATING EFFECTIVE MIDDLE GRADES INSTRUCTIONAL PRACTICES IN A TEACHER-RESEARCHER ALLIANCE

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One of the most intransigent problems in mathematics education is the culturally-influenced divide between classroom practice and educational research. This paper describes our explicit attempt to bridge that divide by translating research on instructional practices linked to improving students' mathematics achievement into a brief guide outlining constructs, features, strategies, routines, and tools for use in a teacher-researcher alliance. We outline the design and development process, share the guide itself, and summarize data addressing the utility of the guide for a research and professional development project in which 100 U.S. Grades 6-8 teachers are collaborating to improve middle grades modeling and problem solving achievement.

Keywords: instructional activities and practices, teacher education - inservice / professional development, middle school education

The persistent, culturally-situated divide between educational research and teaching practice in school mathematics is well documented (Cai *et al*., 2017). In addition to vastly different contexts and goals, one reason for the teacher-researcher divide arises from communication - researchers and teachers rarely interact as colleagues, researchers typically disseminate findings in ways that foreground abstractions of teaching and learning, and teachers often seek out specific, situated tools for their everyday practice (Labaree, 2003). One area of common ground centers around shared goals among teachers and researchers to generate information about "what works" in particular contexts in hopes they may inform educators in other contexts (Krainer, 2014). An emerging model for nurturing that common ground is to establish a *Teacher-Researcher Alliance for Investigating Learning* [TRAIL] (Koichu & Pinto, 2018). While the TRAIL format addresses many of the challenges of teacher-researcher collaboration, there are few examples in the literature, and none addressing research aimed at investigating instructional methods for improving student mathematics achievement. Recently, we have engaged in an intentional effort to build a U.S. teacher-researcher alliance centered around investigating and articulating effective instructional routines to promote modeling and problem solving achievement among Grades 6-8 students. One of the first efforts within our alliance has been to create a 2-page instructional practices guide that communicates findings from research in ways that support teachers' translation into practice.

The framework we have developed is organized around the constructs of *Explicit Attention to Concepts* (EAC) and *Student Opportunities to Struggle* (SOS) (Hiebert & Grouws, 2007). Hiebert and Grouws (2007) identified EAC and SOS as broad clusters of instructional methods which researchers have linked to increases in student achievement. In this paper, we describe efforts to form a teacher-researcher alliance to further articulate features, strategies, and routines for EAC and SOS instructional practices, with the specific aim of supporting teachers' implementation of these constructs in their classrooms. We emphasize our methods for translating research findings into actionable practices, especially our engagement with 100 teachers as partners in investigations the effectiveness of the associated instructional routines for improving student achievement.

Perspective(s) or Theoretical Framework

The driving motivation for this research project is an optimistic belief in the capacity of teachers and researchers to collaborate for improving student achievement. Broadly, large-scale analyses suggest teacher factors account for about 30% of the variation in student's mathematics performance, second only to student factors - which account for about 50% of variation - and exceeding all other remaining identified factors combined (Hattie, 2003). In addition, literature suggests mathematics teachers can (and do) serve as co-producers of relevant professional knowledge with researchers, while directly improving outcomes for their students and affecting positive changes in their local contexts (Kieran, Krainer, & Shaughnessy, 2012). Locally, our prior work with hundreds of teachers through a university-based professional development center has led our team of researchers to view mathematics teachers as having rich, varied expertise, with pragmatic insights from adapting and enacting curriculum in their schools. For this project, we leaned into that perspective by seeking a way to situate our research within a broader effort to bridge cultures through a mutually-valuable partnership centered around shared goals for improving student achievement.

Teacher-Researcher Alliance

Historically, relationships between university researchers and teachers have been asymmetrical; teachers are positioned as in need of the knowledge that researchers provide, with little acknowledgement of the value the experiential knowledge of teachers (Gore & Gitlin, 2004). Ironically, the knowledge produced by researchers often does not have the practical and contextual information that teachers find useful for their practice (Gore & Gitlin, 2004; Krainer, 2014). To bridge the cultures of teaching and research, we must recognize different ways of knowing and view relations as symmetries rather than hierarchies (Krainer, 2014). Central to this perspective is a view of teaching as an ongoing process of experimentation in which teachers naturally engage in regular testing of often informal hypotheses about student's abilities, the effects of instructional activities, and learning outcomes (Cobb, 2000). Researchers can play a role in that experimentation, helping to coordinate activities, gather evidence for drawing inferences, and plan for implementation of teacher-led interventions.

In particular, we conceptualize this project through the five features in the Teacher-Researcher Alliance for Investigating Learning (TRAIL) theoretical framework for scalable partnerships between educational researchers and teachers (adapted from Koichu & Pinto, 2018):

- **Professional Growth** - through participation, teachers enhance their educational research competencies, researchers build their knowledge and abilities to engage in classrooms.
- **Authenticity** - teachers engage in substantive research around questions drawn from real problems of practice, researchers match methodology to existing school systems.
- **Shared Agency** - mechanisms are established so teachers and researchers can each advance individual needs and goals, with room for personal expression and creativity.
- **Choice** - the partnership includes a network of projects, run simultaneously, so that teachers can select from a menu of options for participation.
- **Creating and Using Knowledge** - opportunities for determining "what works" flows from both teaching and research; practical knowledge is co-created.

EAC & SOS Instructional Practices

Nearly all mathematics professional development programs are designed to improve student learning by attempting to affect teachers' knowledge, beliefs, and instructional practices. However, student achievement is a distal goal for programs primarily focused on teachers, and there is limited research demonstrating even modest effects of professional development programs on student achievement (Gersten *et al.*, 2014; Kennedy, 2016). To design professional development with the greatest potential to positively impact instruction and student achievement, our project has focused on instructional strategies identified in research literature as most likely to improve student learning. Hiebert & Grouws' (2007) synthesis of research on instructional strategies with evidence for improving students' mathematical learning has been our primary touchstone.

Hiebert and Grouws identified two constructs underlying instructional practices supporting conceptual understanding (defined as "the mental connections among mathematical facts, procedures, and ideas", p. 382) with research evidence indicating positive effects across study design, teaching formats, and contexts (p. 387):

- **Explicit attention to concepts** (EAC) - Teachers and students explicitly discuss mathematical concepts and make connections among concepts, facts, and procedures through activities such as questioning, discussing, comparing, and relating.
- **Student opportunity to struggle** (SOS) - Students engage in productive struggle with important mathematical ideas through sense-making around comprehensible problems that require them to"figure something out that is not immediately apparent".

EAC can be seen as a more externally mediated approach in which the teacher ensures concepts and connections are made public and clear to students. In contrast, SOS is focused on experiences that engage students in developing understandings through their own sense-making activity. Recently, Stein, Correnti, Moore, Russell, and Kelly (2017) found group means on achievement measures were significantly higher for students of teachers who self-reported a preference for, as well as demonstrated through video-recorded instruction, instructional practices centered around EAC and SOS. Students whose teachers aligned with EAC alone performed significantly better than students of teachers aligned with SOS alone, who in turn performed better than students of teachers aligned with neither element. Additionally, several studies have shown that SOS positively impacts student achievement, particularly when it precedes EAC practices (Kapur, 2014; Loehr, Fyfe, & Rittle-Johnson, 2014; Schwartz, Chase, Oppezzo, & Chin, 2011).

Methods

The goal of this project was to establish a teacher-researcher alliance (with TRAIL features) in order to articulate instructional practices for the purposes of an extended research project in the context of professional development. To put the research in context, we next provide (a) a brief overview of the project, (b) a description of the project team members who developed the framework, (c) a summary of our process for developing a framework related to the EAC and SOS constructs, and (d) a brief description of the associated data collection and analysis.

Project Overview

The heart of this project is a group of 100 Grades 6-8 teachers across 45 schools and 23 districts working in an area spanning approximately 200 miles of a U.S. state with low population density and a strong tradition of local control in education. Funded by a multi-year federal research grant to investigate methods for improving middle grades mathematics achievement, the researchers recruited the teachers by obtaining approvals from their respective district administrators to invite Grades 6-8 mathematics teachers to participate in a 3-year research-professional development partnership. The professional development (PD) involves (a) three module meetings (15 hours total) for collaborative development of the EAC and SOS framework with opportunities for classroom implementation between each session, followed by (b) three week-long summer institutes (one each summer) for planning teacher-led classroom studies of EAC and SOS instructional routines, and (c) embedded classroom support provided by an experienced, dedicated instructional support team (the PD Team).

The PD Team plays a pivotal role in our teacher-researcher alliance by bringing together personnel to bridge the research-practice divide through developing and implementing PD to support teachers' implementation of EAC and SOS instructional practices in their classrooms. The PD team includes a math professor, a math education professor, three full-time mathematics instruction specialists (similar to coaches), a postdoctoral researcher, and a graduate student. The team has extensive expertise and knowledge in mathematics education and professional development. Four of the PD Team members have taught mathematics at the secondary level in the local area for between seven and 16 years, three PD Team members have worked as math coach/specialists for between five and eight years, and four PD Team members have masters or doctoral degrees in mathematics education.

Development of an EAC-SOS Guide

In collaboration with the researchers and teachers, the PD Team led the development of a 2-page **EAC-SOS Guide**. The PD Team met weekly for three months to expand and interpret the conceptual and research foundations of EAC and SOS instructional practices, with a primary purpose of communicating research findings in ways deemed relevant and useful among teacher participants. Using Hiebert & Grouws' (2007) and Stein et al. (2017) as initial resources, the PD Team unpacked the research concepts and associated studies in the context of situated instructional practices. The central challenge of the development work was to communicate instructional routines under investigation by the researchers in ways that maintain fidelity to the research supporting EAC and SOS as effective for promoting students' mathematics achievement while clarifying distinguishing features and levels of specificity that are necessary for teachers to translate the research to their day-to-day instruction. Eventually, the EAC-SOS Guide came to include separate pages for EAC and SOS as **constructs** of instructional practices with robust research evidence supporting positive effects on development of mathematics students' conceptual understanding. For each construct (identified by a distinguishing color and icon), the guide lists three **features** of mathematics instruction characterized by the respective constructs, as well as four **strategies** teachers can engage in during classroom instruction and two **routines** per strategy selected by the researchers to be further investigated through clinical cross-over trials in the teachers' classrooms (see Figure 1 for the design template). Based on teachers' feedback on early drafts, each strategy was supplemented by a short list of instructional tools which may be well-suited to implementation of the associated routines.

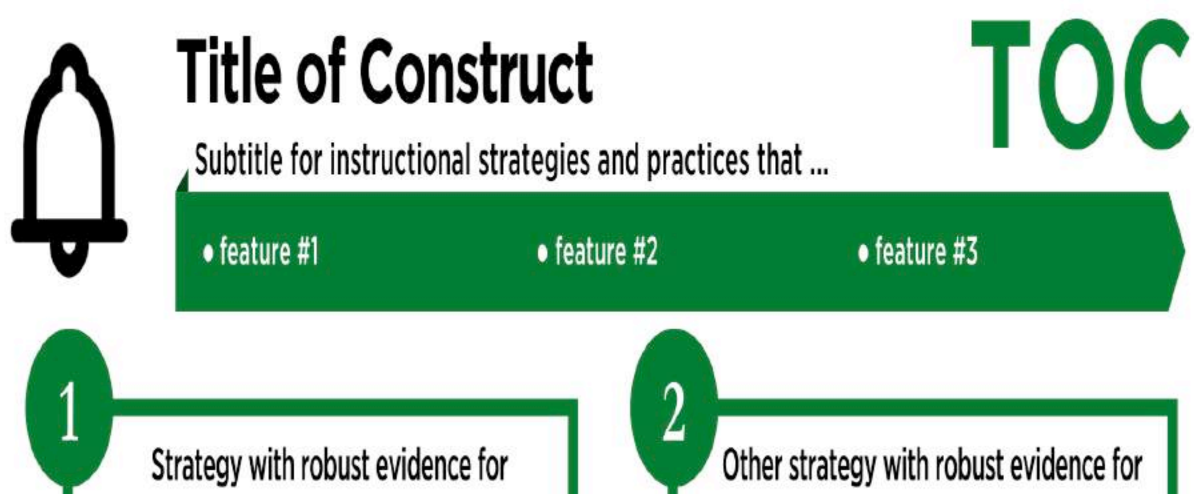

Figure 1. Design Template for the EAC-SOS Guide, with features, strategies, routines, and tools.

Data Sources

We used the PD modules to evaluate and refine the articulation of instructional practices in the EAC-SOS Guide. Participating teachers completed a Teaching Context Survey (adapted from Stein *et al*., 2017), addressing their beliefs and current practices surrounding EAC & SOS instruction, as well as curricular formats, school characteristics, instructional content, and related factors needed to estimate effects of instructional interventions on student achievement across teachers' individual contexts. During the first PD module, teachers previewed the Guide, recommended changes to better support implementation, and rated their level of familiarity and experience with the 8 strategies listed in the guides. Teachers each also selected one of the 8 strategies they would like to try first in their classrooms, and completed a "Stop Light" reflection at the next professional development meeting to communicate the challenges they encountered (red light), ways in which the PD Team can support implementation (yellow light), and positive outcomes they saw in their classroom practice (green light). In the Results section below, we present the final EAC-SOS Guide and summarize the teachers' strategy selections.

Results

The EAC-SOS Guide (see Figure 2, or http://bit.ly/eac-sos-guide) is the primary result of our collaboration among teachers and researchers to articulate instructional constructs, features, strategies, routines, and tools supporting research into the improvement of student mathematics achievement. Following the first PD Module, 94 teachers selected a routine to try in their classroom. More teachers selected an SOS routine (59%) instead of an EAC routine (41%). Teachers' rationales for their choice of an SOS or EAC routine are summarized in Table 1.

Table 1. Counts of rationale provided for teachers' selected routines, by construct.

	Supporting Student Thinking	Fit with Curriculum	Improving Teaching Skills	Fit with Content	Other (Collaboration, General Interest)	*Total*
EAC	15	10	2	9	3	*39*
SOS	24	8	16	6	1	*55*
Total	*39*	*18*	*18*	*15*	*4*	*94*

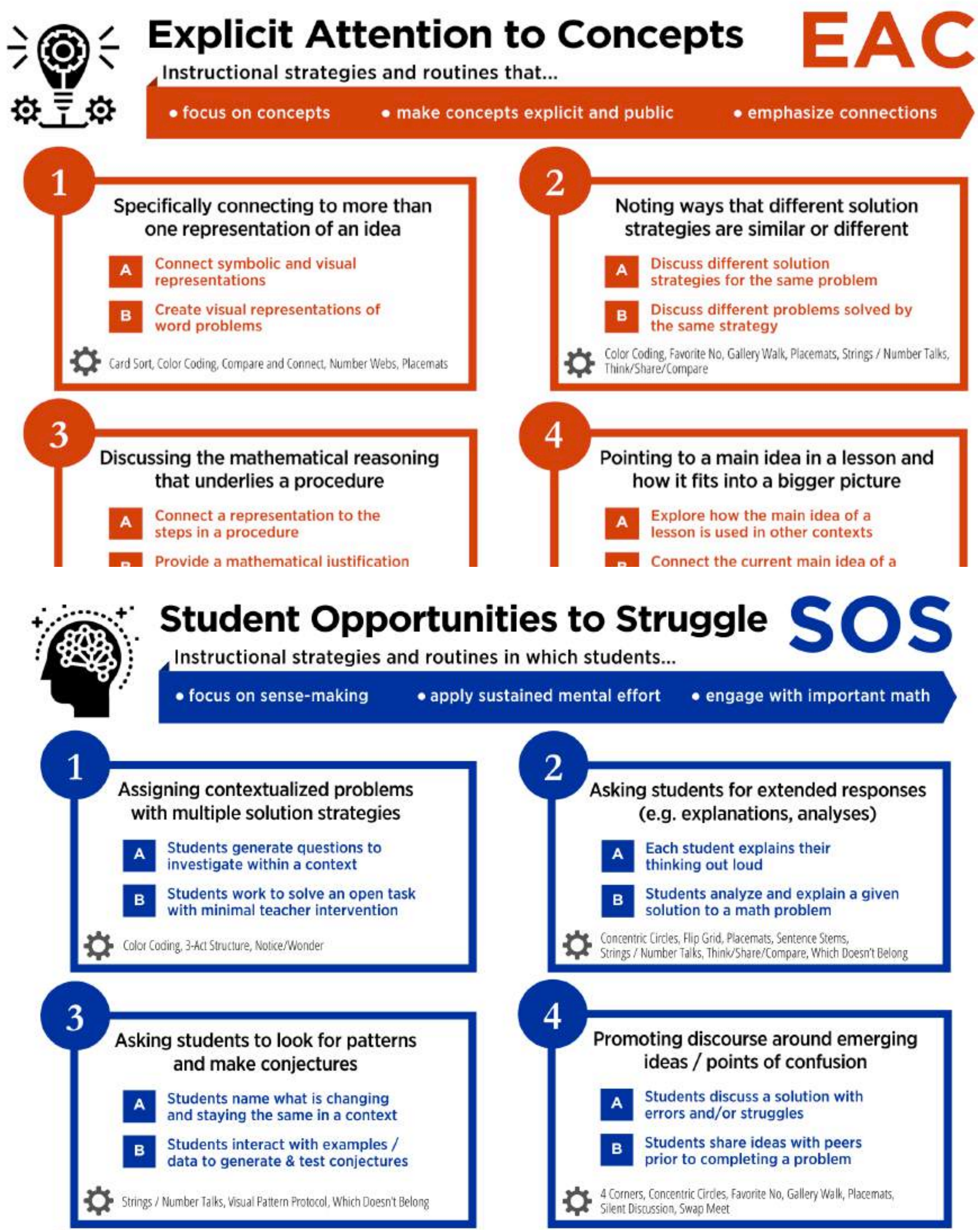

Figure 2. EAC-SOC Guide to Instructional Practices for Improving Math Achievement

Table 2 shows the routines selected by teachers for initial testing, together with exemplar statements related to why that particular routine was selected. (The examples were selected based on a combination of frequency of occurrence of 'why' reasoning across multiple responses in conjunction with those that seem well tied to the routine itself.).

Table 2. Routines selected by participating teachers, with example rationales they provided.

Routine	Frequency	Example Whys?
EAC1A: Connect symbolic and visual representations	7.4% (7)	...Many of my students are procedural, but they actually don't understand the nature of the problem and what it's saying.
EAC1B: Create visual representations of word problems	10.5% (10)	My students have been taught a lot of procedures and do not always understand what it looks like...
EAC2A: Discuss different solution strategies for the same problem	10.5% (10)	Students will use various methods to solve systems of equations and I would like to have them compare and contrast the different strategies.
EAC2B: Discuss different problems solved by the same strategy	0.0% (0)	*No exemplars*
EAC3A: Connect a representation to the steps in a procedure	4.3%(4)	I'm hoping that an explicit connection to steps in a procedure to a context will help with understanding systems of equations.
EAC3B: Provide a mathematical justification for the steps in a procedure	3.2% (3)	...it is important for my students to be able to explain how they work through a problem and also collaborate with peers...
EAC4A: Explore how the main idea of a lesson is used in other contexts	3.2% (3)	Because this will relate to what I am currently teaching students. Relate percents to fractions
EAC4B: Connect the current main idea of a lesson to a prior math concept	5.3% (5)	I will be starting out percent lessons next week...I want to focus on making connections to what they did with ratios & proportions.
SOS1A: Students generate questions to investigate within a context	2.1% (2)	I always ask them questions but they rarely ask each other questions. I feel like we all need to improve in this.
SOS1B: Students work to solve an open task with minimal teacher intervention	8.5% (8)	I want to see the productive struggle with my students and see how the handle it.
SOS2A: Each student explain their thinking out loud	10.5% (10)	I think understanding becomes more clear and cemented in our brains when we can express them in words.
SOS2B: Students analyze and explain a given solution to a math problem	2.1% (2)	Teaching Intervention math my students often just want to say the answer instead of explain how they arrived at that answer.
SOS3A: Students name what is changing and staying the same in a context	5.3% (5)	I want to incorporate more "non-teacher directed" entry point activities and I feel that this is a place to start...
SOS3B: Students interact with examples or data to generate and test conjectures	4.3%(4)	...I want my students to interact with data to understand how adding/subtracting numbers from the data will affect the mean and median.
SOS4A: Students discuss a solution with errors and/or struggles	14.9% (14)	I want students to get more comfortable with analyzing others answers and share ideas
SOS4B: Students share ideas with peers prior to completing a problem	8.5% (8)	...Students can bounce and gain ideas that they may not have thought of or get reinforcement on an idea they had.

Discussion

The primary outcome of this research is the EAC-SOS Guide. The time and resources supporting the design and development of the document - especially the associated efforts to situate the development within a teacher-researcher alliance - indicate great potential value in the document to support efforts to address the culturally-entrenched challenges of merging research and practice in the context of professional development aimed at improving mathematics achievements in the middle grades. In addition to the direct input teachers had in the development of the Guide itself, teachers' initial selections of routines to try in their classrooms also provides positive indications that both EAC and SOS constructs are appealing to practicing teachers interested in better understanding and leveraging their students' thinking, implementing their curriculum, improving their repertoire of teaching methods, adapting their instruction to the mathematical content, and collaborating with peers.

In addition to practical uses for the EAC-SOS Guide in professional development and research settings, we encourage colleagues to consider transferring our conceptual framework, especially the TRAIL model for collaboration between teachers and researchers and emphasis on articulating research findings in practical terms, to future projects. We view the results reported in this paper as provisional, and intend to further refine and articulate the constructs, features, strategies, routines, and tools by creating a modern website using similar development methods (e.g., selection preferences, challenges, affordances, supports, evidence for positive effects). In addition, we look forward to conducting classroom research with our teacher partners, and are hopeful the associated research findings will clarify the contexts under which the instructional routines are especially promising for classroom implementation. We welcome collaborators interested in extending that work.

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