SCHOOL SCIENCE AND MATHEMATICS

Research to Practice Article
Using the PSM6 to Make Adjustments to Middle School Mathematics Instruction

Based on the published SSM Journal Research Manuscript:
Companion to *Measuring Sixth-Grade Students' Problem Solving: Validating an Instrument Addressing the Mathematics Common Core*

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This manuscript describes how a middle school mathematics team used the Problem Solving Measure for sixth-grade (PSM6) students to assess middle school students' outcomes at the end of the academic year. A goal was to use the results to make instructional decisions for the following year. Results from the PSM6 fostered conversations about possible instructional changes that might be useful in districts using the Common Core State Standards.

The Common Core State Standards for Mathematics (CCSSM) emphasize mathematical problem solving. It is found in several Standards for Mathematical Practice (SMPs) and is incorporated into multiple Standards for Mathematics Content [SMCs] (Kanold & Larson, 2012). For instance, the title of the first SMP is "Make sense of problems and persevere in solving them" (Common Core State Standards Initiative [CCSSI], 2010, p. 6). According to this SMP, "Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals" (CCSSI, 2010, p. 6). Relatedly, one example of a sixth-grade SMC with a problem-solving focus is 6.RP.A.3, "Use ratio and rate reasoning to solve real-world and mathematical problems" (CCSSI, 2010, p. 42). It is evident how problem solving permeates the standards and should necessarily permeate mathematics teachers' teaching and assessment.

Overview and Research Focus

Bostic and Sondergeld (in press) justify the validity and reliability of the Problem Solving Measure for sixth-grade students (PSM6) as an assessment for sixth-grade students' problem-solving performance related to CCSSM content. The lead author of this manuscript is a member of a middle school mathematics team at a Midwest school. The team was familiar with the PSM6 and had two goals for its use: (1) examine sixth-grade students' mathematics problem-solving ability and (2) explore seventh-grade students problem-solving ability related to sixth-grade CCSSM content. Put another way: (a) How well can sixth-grade students problem solve? and (b) To what degree did seventh-grade students retain knowledge needed to solve sixth-grade problems? Reflection upon these goals aimed to promote change for the upcoming year and build stronger connections between sixth- and seventh-grade mathematics instruction.

Few, if any, measures are validated to examine students' problem-solving performance related to CCSSM content like the PSM6. A challenge for teachers, including our team, is whether and how to make changes based on poorly validated tests, much less wait for results from high-stakes test administrations that will not be delivered until months after the new academic year has started. Validated measures such as the PSM6 encouraged dialogue among our team because of its unique focus and evidence connected to problem solving, SMCs, and SMPs. In total, 98 sixth-grade and 105 seventh-grade students completed the PSM6 during one administration window that lasted two class periods (i.e., 100 total minutes). The team scored responses as correct or incorrect, took notes about students' problem-solving strategies, and made fieldnotes during the PSM6 administration.

Findings

Results from the PSM6 raised some positive takeaways and some concerns for our team. Broadly speaking, students in both grade levels struggled to obtain correct solutions to most items. Sixth-grade students' raw score average was 2.58 (SD = 0.17). Seventh-grade students' raw score average was 4.66 (SD = 0.31). Thus, it was evident that seventh-grade students' answered more items correctly than sixth-grade students.

One positive takeaway from test administration was that students gave appropriate effort and persisted during the measure. They persevered while problem solving, a trait described in SMP1. It was typical for students to respond incorrectly to a problem but at least they identified an appropriate entry point during problem solving. A second positive takeaway was that students often were capable of performing a procedure to solve the problem, which suggests they attended to procedural understanding, a facet of mathematical proficiency.

After reflecting upon results and students' strategies, we concluded that our concerns were that (1) students lacked critical thinking skills that the team thought they developed during the year and (2) students struggled with the contextual features of the problems. A common student response to a ratio and proportions task provides an example supporting these two conclusions. The task reads:

> A group of 150 tourists were waiting for a shuttle to take them from a parking lot to a theme park's entrance. The only way they could reach the park's entrance was by taking this shuttle. The shuttle can carry 18 tourists at a time. After one hour, everyone in the group of 150 tourists reached the theme park's entrance. What is the fewest number of times that the shuttle picked tourists up from the parking lot?" (Bostic & Sondergeld, in press)

Students identified an entrance point to the problem and performed the division algorithm to conclude the number of trips needed to transfer every person from the parking lot to the park entrance; however, the contextual nature of the problem caused struggle for students. Any fraction or decimal response to this task is nonsensical; however, a majority of sixth- and seventh-grade students' answers included decimals (e.g., 8.3 trips). The contextual nature and rigor of the task caused the solution pathway to be less algorithmic and makes the cognitive demand of the task to be more aligned with Smith and Stein's (2011, 1998) description of procedures with connections. Procedures with connection tasks usually require individuals' focused cognitive energy as well as multiple representations during problem solving (Smith & Stein, 1998). These findings raised our team's awareness of students' problem-solving abilities and provided evidence to ground discussion about what to do next year.

Implications for Practice

The team drew on these results to make changes for future instruction, which may also be considerations for other middle school teachers. First, the PSM6 highlighted the importance of exploring instructional strategies that promote problem solving during instruction. Our team intends to offer support and guidance throughout problem-solving instruction by encouraging more peer-to-peer mathematical discourse and prompting students to justify their strategies and solutions. Secondly, we also agreed to refrain from using exercises exclusively as the way to learn a new strategy. Instead, we will offer exercises and problems like those on the PSM6 as a way for students to discover a rule and understand shortcuts within the frame of viable problem-solving strategies. The National Council of Teachers of Mathematics [NCTM] has consistently advocated for such instruction, including in their most recent publication of *Principles to Actions* (NCTM, 2014). Finally, our team will maintain an emphasis of procedural understanding; however, students need opportunities to demonstrate mastery of mathematical procedures within the frame of worthwhile tasks arising from everyday life, their communities, society, and potential workplaces. Thus, we will use challenging problems during future instruction that encourage students to think about how to solve them and reflect on the appropriateness of the strategy for the situation.

Resources to Support Further Discussions

Teachers might consider using the PSM6 as our team did to uncover ways a team of teachers can work collaboratively to improve mathematics teaching and learning. Our team drew on a couple resources to assist in focusing our efforts. The first was Smith and Stein's (2011) *Five Practices for Orchestrating Productive Mathematics Discussions*. The text describes how to set instructional goals and select an appropriate task to meet the goals, with descriptions and examples of tasks that promote higher cognitive demand. Then, it discusses the five practices through narratives of two classroom teachers. These facets make it a necessary text for teachers seeking to reflect on task rigor and facilitating mathematical discourse about those tasks. The second resource is NCTM's *Principles to Action* (2014), which is a call to action for teachers, teacher leaders, curriculum coordinators, and others. The ideas and examples resonated with our team and assisted departmental discussions about what is working (e.g., perseverance) and possible changes (e.g., implementing tasks that foster reasoning and problem solving). We suggest that teams of teachers find time to collaborate and discuss results and implications for their practice as a team like we did. These discussions were fruitful and brought the middle school mathematics team together to make changes that cut across grade levels and teachers' classrooms.

References

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