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Exploring Validity and Reliability for the Revised SMPs Look-For Protocol

Jonathan D. Bostic
Bowling Green State University, bostic@bgsu.edu

Gabriel Matney
Bowling Green State University, gmatney@bgsu.edu

Toni Sondergeld

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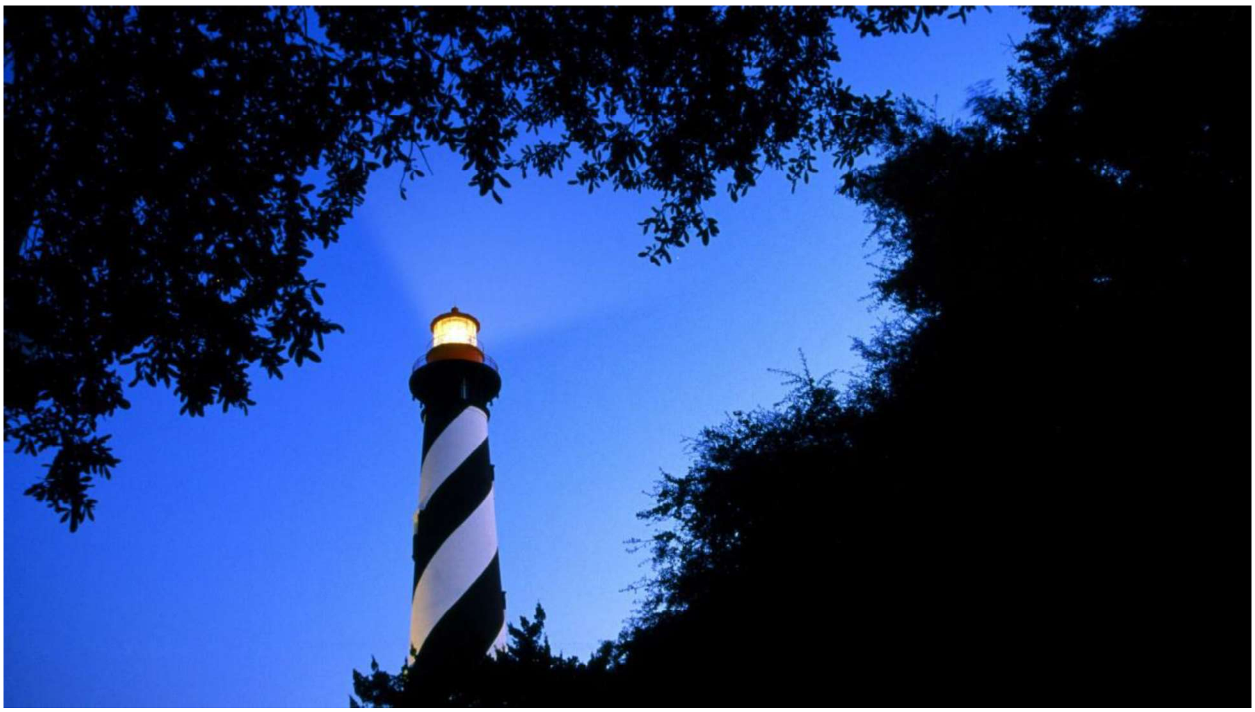

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RCML History

The Research Council on Mathematics Learning, formerly The Research Council for Diagnostic and Prescriptive Mathematics, grew from a seed planted at a 1974 national conference held at Kent State University. A need for an informational sharing structure in diagnostic, prescriptive, and remedial mathematics was identified by James W. Heddens. A group of invited professional educators convened to explore, discuss, and exchange ideas especially in regard to pupils having difficulty in learning mathematics. It was noted that there was considerable fragmentation and repetition of effort in research on learning deficiencies at all levels of student mathematical development. The discussions centered on how individuals could pool their talents, resources, and research efforts to help develop a body of knowledge. The intent was for teams of researchers to work together in collaborative research focused on solving student difficulties encountered in learning mathematics.

Specific areas identified were:

1. Synthesize innovative approaches.
2. Create insightful diagnostic instruments.
3. Create diagnostic techniques.
4. Develop new and interesting materials.
5. Examine research reporting strategies.

As a professional organization, the **Research Council on Mathematics Learning (RCML)** may be thought of as a vehicle to be used by its membership to accomplish specific goals. There is opportunity for everyone to actively participate in **RCML**. Indeed, such participation is mandatory if **RCML** is to continue to provide a forum for exploration, examination, and professional growth for mathematics educators at all levels.

The Founding Members of the Council are those individuals that presented papers at one of the first three National Remedial Mathematics Conferences held at Kent State University in 1974, 1975, and 1976.

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Elucidating Teachers' Opportunities to Learn

Kindling Diverse Thinking about Mathematics Learning

EXPLORING VALIDITY AND RELIABILITY FOR THE REVISED SMPS LOOK-FOR PROTOCOL[1]

Jonathan Bostic
Bowling Green State University
bosticj@bgsu.edu

Gabriel Matney
Bowling Green State University
gmatney@bgsu.edu

Toni Sondergeld
Drexel University.
Tas365@drexel.edu

The Standards for Mathematical Practice (SMPs) describe mathematical behaviors and habits that students should express during mathematics instruction. Thus teachers should promote them during classroom-based mathematics instruction. The purpose of this manuscript is to discuss the validation process for an observation protocol called the Revised SMPs Look-for Protocol, which is meant to fill this gap. An implication of this study is that users with a robust understanding of the SMPs may feel confident using the protocol as a validated and reliable tool in research and school-based settings.

As of 2015, 42 of 50 states within the United States of America have adopted the Common Core State Standards for Mathematics (CCSSM) as their mathematics standards. The CCSSM has Standards for Mathematics Content and Standards for Mathematical Practice (SMPs; Common Core State Standards Initiative [CCSSI], 2010). SMPs are descriptions of mathematical habits and behaviors and are deeply connected to the National Council of Teachers of Mathematics' process standards (Kanold & Larson, 2012; Koestler, Felton, Bieda, & Otten, 2013). While the CCSSM have been in place for nearly five years, teachers are still struggling to make sense of them, especially the SMPs (Bostic & Matney, 2014). At times, it is unclear to teachers and observers what the SMPs look like during classroom mathematics instruction (Bostic, 2015; Bostic & Matney, 2014). For example, *modeling with mathematics* has a meaning distinct from *modeling as representation* discussed in the K-5 content standards and *mathematical modeling* as described in the high school content standards (Bostic, 2015; Bostic, Matney, & Sondergeld, 2016). As such, education stakeholders may benefit from having a tool to generate feedback about the ways mathematics teachers' instruction promotes the SMPs. The aim of this manuscript is to present evidence connected to validity and reliability for a tool focused on teachers' instruction related to the SMPs. This tool is called the *Revised SMPs Look-for Protocol*.

Literature Review

Prior Validated Tools for Examining Classroom Instruction

There are various tools to examine mathematics instruction. Boston, Bostic, Lesseig, & Sherman (2015) discusses the strengths and limitations of three validated tools used often in educational research (i.e., Reformed Teaching Observation Protocol, Instructional Quality Assessment, and Mathematical Quality of Instruction). Unfortunately, all three were not intended for use in exploring teachers' promotion of the SMPs. On the other hand, the *Mathematics Classroom Observation Protocol for Practices ($MCOP^2$)* responds to the need for a tool that examines the SMPs (Gleason & Cofer, 2014). "Each of the items on the *$MCOP^2$* was designed to coordinate with a Standard for Mathematical Practice…for instance, item #9 on the protocol is 'The lesson provided opportunities to examine elements of abstract (symbolic notation, patterns, generalizations, conjectures, etc.),', matching the second Standard for Mathematical Practice that instructors should be aiming to teach their students" (Gleason & Cofer, 2014, p. 96). The *$MCOP^2$* moves the field forward with a validated tool to examine classroom instruction for the SMPs; however, this observation protocol has been validated for its use with undergraduate mathematics instruction and not for K-12 instruction. Thus, there still exists a need for a validated observation protocol related to K-12 teachers' SMP-focused instruction.

Development of the Standards for Mathematical Practice Look-for Protocol

A year after the large-scale adoption of the CCSSM, Fennell, Kobett, and Wray (2013) created a tool called the Standards for Mathematical Practice Look-for Protocol (*SMP Look-for Protocol*). Their goal was to develop and share a tool to gather evidence related to K-12 mathematics teachers' promotion of the SMPs during classroom instruction. An initial version had only one indicator related to each SMP for teachers' promotion of the SMPs and students' engagement in the SMPs. Later versions included observable mathematical behaviors and habits (as many as eight), related to both teachers' and students' observable mathematical behaviors and habits. A final version of the *SMP Look-for Protocol* was shared at the 2013 Association of Mathematics Teacher Educators' annual meeting. Fennell and his team conducted nearly 300 observations and asked numerous mathematics teacher educators, curriculum coaches, and teachers to examine the protocol for their ideas related to it. Synthesizing across groups' voices, it was clear that the protocol was helpful to examine K-12 teachers' promotion of the SMPs during classroom instruction. Fennell and colleagues further shared openness to additional revisions of the protocol. Moreover, they had not conducted a formal validation study to use the tool in real-time or video-recorded K-12 classroom mathematics observations. The purpose of the present study is to revise and validate this tool for the purpose of analyzing K-12 teachers' promotion of mathematical behaviors and habits framed by the CCSSM SMPs. Our research question is: What evidence supports use of the *Revised SMPs Look-for Protocol* as a tool to examine teachers' mathematics instruction related to promotion of the SMPs?

Method

Context

A validation study for an observation protocol should possess eight stages (Artino, La Rochelle, Dezee, & Gehlbach, 2010; Smith, Jones, Gilbert, & Wieman, 2013). They are (1) conduct a literature review; (2) conduct interviews and focus groups to gather more ideas for items; (3) synthesize data from literature review and focus groups; (4) develop items; (5) conduct expert panel validation; (6) conduct cognitive interviews with potential users of the protocol; (7) conduct pilot testing of protocol; and (8) conduct psychometric analysis using data from the protocol (e.g., reliability analysis). After nearly 60 observations with the protocol (Fennell et al., 2013), our research team felt it was missing some elements related to teachers' promotion of the SMPs. To that end, we conducted stages one though eight, which involved forming focus groups, an expert panel, and working alongside potential users of the tool. These groups, panels, and users included K-12 mathematics teachers, mathematics coaches, curriculum coordinators, mathematics instructors teaching mathematics education courses, and mathematics teacher educators from across the USA who have led professional development focused on the SMPs, including the initial developers of the protocol Fennell, Kobett, and Wray. As a result, we added some observable aspects related to the SMPs and modified some aspects to better capture teachers' instruction that promoted the SMPs. It is this *Revised SMPs Look-for Protocol* that we explore in our current validation study.

Instrumentation

The *Revised SMPs Look-for Protocol* includes two or three observable behaviors related to teachers' promotion of the SMPs as well as specific notes for observers. A selection of the protocol is shared in Figure 1. For instance, an indicator for "SMP 1: Make sense of problems and persevere in solving them" (CCSSI, 2010, p. 6) is "Provide opportunities for students to solve problems that have multiple solutions and/or strategies".

Mathematical Practices	Observable Teacher Moves Related to Practices
SMP 1. Make sense of problems and persevere in solving them	☐ A. Involve students in rich problem-based tasks that encourage them to persevere in order to reach a solution ☐ B. Provide opportunities for students to solve problems that have multiple solutions. ☐ C. Encourage students to represent their thinking while problem solving NOTE: Task must be a grade-level/developmentally-appropriate problem. That is, a solution is not readily apparent, the solution pathway is not obvious, and more than one pathway is possible. Comments:

Figure 1. A selection of the Revised SMPs look-for Protocol.

Data Collection

Since an initial protocol was developed previously and our intention was to work towards a revised protocol, we began with stage two of the validation process. For stages two, five, and six of the validation process data were collected from an expert panel consisting individuals from five groups: K-12 mathematics teachers, mathematics coaches, curriculum coordinators, mathematicians, and mathematics teacher educators. For stage two, we communicated with these individuals to make sense of their ideas for a possible tool to gather data about K-12 teachers' promotion of the SMPs during instruction. These data, in addition to a thorough review of relevant literature on the SMPs published since 2010, led to adding and modifying indicators (stage four), and ultimately convening an expert panel of individuals with different backgrounds. At the fifth stage, the panel examined the *Revised SMPs Look-for Protocol* and reflected on the degree to which our revisions and previous statements adequately met the descriptions in the SMPs. For stage six, small-group and one-on-one interviews were made with one member from each group found on the expert panel to further explore their ideas related to its use as a classroom observation tool in research and in teachers' professional development. The goal of these interviews was to learn about the protocol's ease of use and its overall ability to meet the aim of gathering data about K-12 teachers' promotion of the SMPs during classroom mathematics instruction. These data provided evidence for content validity, a measure of the degree to which an item addresses the construct of interest, which is typically examined through the judgment calls of expert panels and cognitive interviews (Gall, Gall, & Borg, 2007).

Data for the quantitative part of this validation study (stages seven and eight) came from two sources. The first source consists of video-recorded data from K-12 teachers located in a

Midwest state that adopted the CCSSM. They participated in one of nine grant-funded mathematics PD programs that lasted a minimum of 100 face-to-face hours during one calendar year. An objective of these PD programs was to foster teachers' sense making of the SMPs so that they might more effectively promote them during classroom mathematics instruction. Teachers consented to providing videos of instruction prior to the PD and again after 80 hours of PD. The second data source consists of observations of live instruction in K-12 classrooms conducted by the authors of this manuscript. In total, 288 observations of teachers' instruction were coded using the *Revised SMPs Look-for Protocol*. Thirty of the 288 observations were made during live instruction while the other 258 were made using videotaped data. Interrater agreement was high across coders (93%), which exceeds the minimum threshold (90%) needed to conduct reliability and factor analysis (James, Demaree, & Wolf, 1984).

Data Analysis

The authors employed inductive analysis (Hatch, 2002) to draw impressions from the interviews and expert panel reviews (stages two, five, and six). Inductive analysis allows users to identify salient themes from data sets (Glaser & Strauss, 1967/2012; Hatch, 2002). Our approach to inductive analysis started with re-reading (or re-listening) to materials (e.g., expert panel written reviews and audio-recorded interviews). Step two was to make memos consisting of initial ideas stemming from this examination of the data. Step three was to reflect on those memos as a way to synthesize them into key impressions, needed as evidence for validity. Step four was to search for evidence within the data sets to support our key impressions. Step five was to search the data for counter evidence. Impressions with a paucity of counter evidence and a large set of evidence were retained. The sixth and final step was crafting clearly written impressions (themes) to share broadly.

Psychometric analysis was conducted during the eighth stage of the validation study was to examine reliability associated with using this tool. Internal consistency (i.e., reliability) was explored in two ways. The first was internal consistency of the protocol using Cronbach's alpha; it indicates the "coefficient of precision from a set of real test scores" (Crocker & Algina, 2006, p. 117). Test-retest reliability using data from pre- and post-PD observations is the second form of reliability evidence investigated. A bivariate correlation was used to determine the relationship between pre-post-PD observations with higher positive relationships indicating a higher level of test-retest reliability.

Results

Impressions from Expert Panel and Interviews

There was a single impression from the inductive analysis. All members involved in the stages consistently agreed that the *Revised SMPs Look-for Protocol* provided a clear vision of gathering meaningful data about K-12 mathematics teachers' promotion of the SMPs. Many on the panel shared how the protocol offered a coherent set of observable aspects related to each SMP. Others who were interviewed supported this. A mathematics teacher commented "This [revised protocol] is helpful for reflecting on what I could be doing in my classroom to promote the SMPs. I feel confident knowing that when I focus on one SMP that my principal, who is a former math teacher, could use this. In fact, I'd prefer that he use this over other observation tools required by our state because we could have a meaningful conversation about ways I might improve my instruction related to the math standards." One mathematics educator shared that the additions found on the revised protocol allowed more teacher moves to be counted as promoting the SMPs, which did not hinder the quality of the observation or overall impressions of the teacher's instruction. He added, "Allowing strategies and solutions to be counted as promoting SMP 1 is more consistent with the literature on problems and problem solving. I'm glad it's there."

Reliability Analysis

Internal consistency was acceptable with a Cronbach's alpha level of .801 for the overall measure. Cronbach's alpha levels between .70 and .90 are considered appropriate for assessments (Tavakol & Dennick, 2011). Measure with internal consistency below .70 could represent an assessment with poorly interrelated items and a measure with internal consistency above .90 could possess too much item redundancy (Tavakol & Dennick, 2011).

Test-retest reliability was acceptable with a correlation coefficient of .721 from pre-PD observation to post-PD observation. This suggests that teacher growth from pre-post-PD is not always consistent across participants. Further investigation of the data clearly demonstrated this phenomenon with teachers performing higher at pre-PD demonstrating less growth by post-PD than teachers who performed lower over time. While conceptually it makes sense that teachers would have the ability to grow more if demonstrating lower levels of performance at pre-PD, it does not allow for production of what are considered good or excellent test-retest reliability coefficients.

Conclusion and Discussion

The purpose of our study was to revise and validate a tool to analyze K-12 teachers' promotion of mathematical behaviors and habits framed by the CCSSM SMPs. We aimed to share validity evidence from cognitive interviews and the expert panel as well as results from internal consistency and reliability analyses. Our content validity evidence was strong hence our conclusion is that the *Revised SMPs Look-for Protocol* appropriately organizes data regarding K-12 teachers' promotion of the SMPs. Internal consistency was strong and relatedly, our test-retest reliability also met the threshold for use in most settings. In sum, a diverse audience may use the *Revised SMPs Look-for Protocol* to gather data about K-12 teachers' promotion of the SMPs during classroom instruction. The protocol may be used with video-recorded data or during live instruction.

This study adds to the growing body of observation protocols validated for use in K-12 mathematics classrooms (see Boston et al., 2015 for a review) and builds upon the Fennel, Kobett, and Wray's (2013) development of a tool to gather observational data about teachers' promotion of the SMPs. Results of our study fill a needed gap as no validated tools currently focus on this area within K-12 instruction. Mathematics teachers, curriculum leaders, and researchers may feel confident using this tool to explore the ways in which teachers foster the SMPs during instruction, and perhaps explore teachers' instructional changes using two or more observations. One caveat with use of this protocol was that everyone who used it had a robust understanding of the SMPs. Observers have either engaged in more than 100 hours of professional development on the SMPs or led professional development on the topic. Thus we do not advocate its use by those unfamiliar with the SMPs or without a coherent understanding of each SMP.

Future Research

While we feel confident with results of this study, we intend to conduct further observations and perform an exploratory factor analysis after more observations. Exploratory factor analysis is appropriate when a researcher has a notion about the nature of the factors measured by an instrument but those factors are not well-defined (Crocker & Algina, 2006). Future researchers might explore the student-version of the protocol developed by Fennell et al. (2013) and explore validity and reliability evidence related to how K-12 students engage in the SMPs during instruction. We also encourage mathematics education researchers to explore connections between the SMPs and the Mathematics Teaching Practices described in *Principles to Action* (National Council of Teachers of Mathematics, 2014). It may be that teachers' promotion of the SMPs might be indicative of one or more Mathematics Teaching Practice, thus relationship to other variables validity evidence should be explored.

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