School Science and Mathematics Association

Founded in 1901

SSMA 2020

Proceedings - Volume 7

119th Annual Convention

November 5 - 7, 2020

Rayelynn Brandl
Julie Herron

Editors

PROCEEDINGS OF THE 119TH ANNUAL CONVENTION OF THE SCHOOL SCIENCE AND MATHEMATICS ASSOCIATION

November 5-7, 2020
Minneapolis, MN USA
Convened Online due to COVID-19

Editors: Rayelynn Brandl, Julie Herron

Cite Proceedings Volume as:

Brandl, R. & Herron, J. (Eds.). (2020). *Proceedings of the 119th annual convention of the School Science and Mathematics Association* (Vol. 7). Minneapolis, MN: SSMA.

Cite Proceedings Chapter as:

Author. (2020). Title of chapter. In Brandl, R. & Herron, J. (Eds.). (2020). *Proceedings of the 119th annual convention of the School Science and Mathematics Association* (Vol. 7). Minneapolis, MN: SSMA.

Website: www.ssma.org

The proceedings are also available via http://www.ssma.org/convention-proceedings

ISBN: 978-1-7343159-1-2

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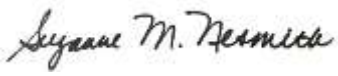
Special thanks to:
The Publications Committee and SSMA members for reviewing and providing valuable feedback on the submitted manuscripts. Special thanks to the many proposal reviewers who assisted Christa Jackson with selection of sessions presented via the virtual conference event.

The School Science and Mathematics Association [SSMA] is an inclusive professional community of researchers and teachers who promote research, scholarship, and practice that improves school science and mathematics and advances the integration of science and mathematics. SSMA began in 1901, and for more than 115 years, SSMA has provided a venue for many of the most distinguished mathematics, science, and STEM educators to offer their presentations of research at our convention and publish their manuscripts in our journal and proceedings. The proceedings of the 119th Annual Convention serve as a testament to the Association's rich traditions and promising future. In light of the Association's first ever virtual convention due to the COVID-19 pandemic, this rich tradition caused me to reflect upon the ways in which the Association and related research, publications, and conventions addressed and responded to previous historical pandemics.

The 1918 influenza pandemic infected almost one-third of the world's population, and the number of deaths were estimated to be at least 50 million worldwide with almost 700,000 deaths occurring in the United States. With no vaccine to protect against influenza infection and no antibiotics to treat the secondary infections associated with the infection, control efforts were limited to quarantine, isolation, use of disinfectants, wearing of masks, limitations of public gatherings, and good personal hygiene, and these efforts were applied unevenly (CDC, 2018).

These eerily familiar descriptions led me to an exploration of our journal during the time of the 1918 epidemic. Though unable to find any articles specifically addressing the 1918 influenza pandemic, I was able to locate a brief commentary by an unknown author in the October 1912 volume of *School Science and Mathematics*. Titled "Epidemics of So-Called Influenza", the commentary recalls the influenza pandemic of 1889-90 "when within one year the whole civilized world was afflicted with the contagion" (p. 592). Following a brief description of lesser outbreaks classified as influenza epidemics and a word of caution in utilizing the classification without satisfactory confirmation by bacteriologists, the author concludes that, "It is to be hoped that in the future such epidemics in various cities will be more systematically and carefully investigated" (p. 592).

I hope you will join me in applauding the astuteness and foresight of our former member, for these words spoken more than 100 years ago still ring true today and stand in tribute to our Association and its members. Let me also applaud and thank you and all SSMA researchers and teachers for conducting and committing in writing your thoughts, results, and reflections, for our works and words have an impact, and you never know how your words and actions may pique the interest or propel the vision of individuals today, tomorrow, or 100 years from now.



Suzanne Nesmith
SSMA Past-President

Centers for Disease Control and Prevention. (2018, March 21). *History of 1918 flu pandemic.* https://www.cdc.gov/flu/pandemic-resources/1918-commemoration/1918-pandemic-history.htm

PREFACE

These proceedings are a written record of some of the research and instructional innovations presented at the 119th Annual Meeting of the School Science and Mathematics Association held virtually on November 5-7, 2020. The original host site for the convention was Minneapolis, Minnesota. The blinded, peer reviewed proceedings includes five papers regarding instructional innovations and research. The acceptance rate for the proceedings was 50 %. We are pleased to present these Proceedings as an important resource for the mathematics, science, and STEM education community.

The SSMA Board of Directors have authored the following position statement regarding published proceedings and journal publications:

> Proceedings authors maintain copyright of articles published in SSMA proceedings and are thus at liberty to submit full versions of their manuscript elsewhere, providing authors follow APA guidelines specific to copyright and duplicate/dual publication. It is the responsibility of the author(s) to identify the identical nature of the papers within any documentation in which the author(s) provide evidence of research productivity.

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BROADENING THE PROBLEM SOLVING MEASURES: MOVING ONLINE

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Bostic and colleagues (2015, 2017) explored the validity evidence for a problem-solving measure (PSM) series when administered in a paper-and-pencil format. Any modifications to a measure or the way it is presented that might impact the score interpretations should be examined carefully. The purpose of this manuscript is to explore further development of the PSMs, specifically investigating an online version and fleshing out the validity argument needed to justify their use in online environments.

Keywords: Assessment, middle grades, mathematics

Introduction

Classroom assessments provide opportunities to promote learning and give teachers data about what and how students are learning (Black, Harrison, Lee, & Wiliam, 2004). Since 2009, a majority of states within the United States of America have adopted the Common Core State Standards for Mathematics (Common Core) in some fashion. The Common Core has a clear focus on problem solving (Common Core State Standards Initiative [CCSSI], 2010) and has two equally important components: content and practice standards. The Standards for Mathematics Content (SMCs) describe what students should learn in each grade level. The Standards for Mathematical Practice (SMPs) communicate behaviors and habits students should experience while learning mathematics in classroom contexts. Problem solving is at the core of the SMPs and found throughout every domain in every grade-level SMC. If students are expected to engage in problem solving within the context of the standards, then their problem-solving performance within the context of the Common Core should be assessed using a measure with strong validity evidence. Measurement without strong validity evidence leads to spurious score interpretations (AERA et al., 2014). Searches for such measures usually return empty (Bostic & Sondergeld, 2015). Therefore, there is great need

for assessments of this nature to be developed so scholars and school district personnel can use them.

Related Literature

Previously, Bostic and colleagues (2015; 2017) presented the Problem-solving Measures (PSMs), which is a test series that assess middle-school students' problem-solving performance related to the SMCs and SMPs. There are three measures, one each for grades six (e.g., PSM6), seven, and eight, which used Rasch modeling (Rasch, 1960/1980) during test construction. A unique feature of these measures is vertical equating (Bostic et al., 2018). Vertical equating with Rasch modeling is only possible when exploring a single, unidimensional construct (Lissitz & Huyunh, 2003; Wright & Stone, 1979). The PSMs have anchor items that allow test takers' scores from any grade level assessment to be measured alongside a single measurement continuum. Thus, test takers' performance remains on a single scale as students matriculate rather than switching from one test's scale to another. This allows for easy interpretation of scores across years and greater use among schools.

For the PSM series, problem solving has been characterized as a process including "several iterative cycles of expressing, testing and revising mathematical interpretations – and of sorting out, integrating, modifying, revising, or refining clusters of mathematical concepts from various topics within and beyond mathematics" (Lesh & Zawojewski, 2007, p. 782). Problem solving occurs only when learners work on a problem. Schoenfeld (2011) frames a problem as a task such that (a) it is unknown whether a solution exists, (b) the solution pathway is not readily determined, and (c) more than one solution pathway is possible. Problems differ from exercises, which are tasks intended to promote efficiency with a known procedure (Kilpatrick, Swafford, & Findell, 2001). Many have argued that word problems students encounter should be complex, open, and realistic (Bostic et al., 2016; Verschaffel et al., 1999). *Complex* problems require reasoning and persistence because a

solution or solution pathway is not clear. *Open* problems allow multiple viable problem-solving strategies and offer several entry points into the task. *Realistic* problems encourage problem solvers to draw on their experiential knowledge and connect mathematics in and out of the classroom. Given these frames for problem solving and problems, coupled with a need for valid, reliable problem-solving assessments, we developed the PSMs to measure students' problem-solving performance within the context of the SMCs and SMPs that allow students' performances to be linked over time.

Objectives of the Study

Validity evidence of these paper-and-pencil measures is available (Bostic & Sondergeld, 2015; Bostic et al., 2017). Score interpretations from the PSMs provide an indication of a student's problem-solving ability as well as a perspective on the degree to which a student understands content described in the Common Core. These are low-stakes tests. Scores are intended to inform teachers' instruction and supplement other data about students' mathematics knowledge and abilities.

Many school districts are moving away from paper-and-pencil tests to online platforms; some have asked about an online version of the PSMs. Online testing is trending because such tests are less expensive, may be scored within minutes, and return with feedback in far less time than paper-and-pencil testing (Paek, 2005). Online administration has potential to change score interpretations; hence, the need for the present study. The research question guiding this study is: To what degree does validity evidence support the use of PSMs being administered online? An objective of this manuscript is to present evidence related to the PSM6, PSM7, and PSM8 when administered using an online platform.

Method

Design

We use the *Standards for Educational and Psychological Testing* (AERA et al., 2014) as a frame for sharing validity evidence. These standards include five sources of evidence: test content, response processes, relationship to other variables, internal consistency, and consequences from testing (AERA et al., 2014). This manuscript reports results from response processes, internal consistency, and consequences from testing. Validity evidence from test content and relationship to other variables are still valid because these areas have not changed.

Participants

Middle school students participated in this Institutional Review Board-approved research. Students' school districts were diverse in nature: rural, suburban, and urban districts. Approximately 40% of the sample came from rural district, 40% came from urban districts, and remaining 20% from suburban locales. In total, 940 sixth-grade, 1006 seventh-grade, and 625 eighth-grade students completed the PSMs in an online environment.

Data Collection and Analysis

Data were collected in two waves. The first wave was a series of cognitive interviews with the intent of gathering response processes and consequences from testing evidence. Teachers recommended students based on ethnicity, gender, and ability, then those students were asked if they wanted to participate voluntarily. The goal was to use representative sampling to achieve a broad understanding about how students might respond to items presented in an online format as well as investigate their perceptions of taking an online test. For each item, students were asked whether they perceived any bias related to the online test. Items were presented by a researcher one-at-a-time to groups of students using an LCD projector. Students were asked to share (a) their perception of any outcomes from online test administration and (b) preference in testing format. In

sum, 23 students of those purposefully selected to represent a cross section across the three grade-levels voluntarily participated in cognitive interviews. All names in this manuscript are pseudonyms.

The second wave was PSM administration using an online platform. This second wave followed students' end-of-course testing, hence students were prepared for their grade-level appropriate measure. PSMs were delivered using Moodle, which is an online platform used worldwide as a course medium. Items were presented one-at-a-time and test takers were instructed to type their response to the constructed-response items. This is similar to the paper-and-pencil version where each item is shown on a single page and test takers are instructed to write their final answer to the constructed response items. Students completed the online measures using tablets, Chromebooks, laptops, and desktop machines (both PC and Mac). Similar to the paper-and-pencil format, students took approximately 75 minutes (on average) but were given more time if needed, which may have spanned two class meetings. Students were provided with scratchpaper, pencils, and calculators. They were able to review their responses to any of the 15 items at any time and reminded to check whether they responded to every item.

Qualitative data from interviews were analyzed using inductive analysis (Hatch, 2002). A goal of inductive analysis is to continuously explore data and generate a theme that adequately describes the phenomenon. Quantitative data were analyzed in the same fashion as the paper-and-pencil format. Items were scored dichotomously (correct/incorrect) and analyzed using Rasch analysis (Rasch 1960/1980). Internal consistency was calculated using Cronbach's alpha.

Results and Conclusions

Response processes

A theme from qualitative analysis of interview data was that all students perceived each item to be solvable, readable, and related to content they learned in class. Maria's comment represented a common sentiment across all participants "The questions seem pretty straightforward. I can read

them and I have bad eyesight…. I think we did a problem like this [working with expressions and equations] a couple months ago." There were no substantive qualitative differences across participants in their responses.

Internal Structure and Reliability

Quantitative results and percentages (see table 1) indicated that students performed satisfactorily using the online platform in two instances: $M_6 = 3.95$ (SD_6=3.43); $M_7 = 6.93$ ($SD_7 = 4.51$); $M_8 = 5.96$ ($SD_8 = 3.81$). The low scores align with the premise shared in previous published work (see Bostic & Sondergeld, 2015, Bostic et al., 2017): problem solving is more difficult than completing exercises. Hence, it is anticipated that students' problem-solving performance might be lower than end-of-course tests that include exercises.

Reliability of the PSMs continued to meet acceptable standards. Cronbach alphas above 0.80 are considered good (Nunnaly, 1978). Cronbach alphas for the online versions of the PSM6, PSM7 and PSM8 were 0.845, 0.880, and 0.826, respectively. This leads to the conclusion that internal consistency of the problem-solving measures in the online platform had appropriate reliability, like the paper-and-pencil versions.

Table 1

Comparison of descriptive statistics for paper-and-pencil and online PSMs

	Mean (SD)		**Percentage (%)**	
	Paper-and-pencil	**Online**	**Paper-and-pencil**	**Online**
PSM6	5.7 (3.1)	3.95 (3.43)	38	26
PSM7	4.88 (3.2)	6.93 (4.51)	26	36
PSM8	3.93 (2.73)	5.96 (3.81)	21	31

Consequences from testing

A qualitative theme from interview data was that test takers preferred to use the paper-and-pencil format; however, they perceived no difference between the paper-and-pencil format and

online format. Lance shared "I'm saying, like, the longer a test is, the more I'd go for computer….and you can always go back and change it [your answer]. Short tests are OK unless there's lots of writing, like in English." Tim shared "It [the online test] doesn't overload [the user]…When you get a big packet of a test [like the paper-and-pencil version]…it's overwhelming. Like your head explodes. One problem at a time, it loads one screen at a time. That's OK." Students generally agreed that they were comfortable doing their work on pencil and paper then transferring it. Tim added, "I can just type in my answer after working it out on paper." Given that they could do their work on paper and pencil; typing their final answer was perceived as a trivial step.

Significance of work to field of Research Evaluation and Assessment in Schools

Drawing together the quantitative and qualitative results, the validity evidence for these sources is strong for using the online version of the problem-solving measures. The PSMs administered online appear to have strong evidence in all three examined validity sources. Score interpretations from PSMs administered online may be treated as similar to those score interpretations from paper-and-pencil PSM administrations (see Bostic & Sondergeld, 2015, 2018; Bostic et al., 2017). Districts and researchers may feel confident using the PSMs in an online platform. Such validity studies are needed to inform potential users and administrators about the appropriateness of validated assessment systems. As more districts trend towards online test administration, it is appropriate to investigate and compare online and paper-and-pencil test administration.

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Acknowledgements

Ideas in this manuscript stem from grant-funded research by the National Science Foundation (NSF #1720646, #1720661; #1920619, #1920621). Any opinions, findings, conclusions, or recommendations expressed by the authors do not necessarily reflect the views of the National Science Foundation.