USING THE SETS INSTRUMENTS TO INVESTIGATE SOURCES OF VARIATION IN LEVELS OF PRE-SERVICE TEACHER EFFICACY TO TEACH STATISTICS

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The authors developed the middle grade and high school Self-Efficacy to Teach Statistics (SETS) instruments based on statistical concepts in United States national and state guidelines for student and teacher knowledge, such as the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Pre-K-12 Report and the Common Core State Standards for Mathematics (CCSSM). The items on both SETS instruments ask teachers to rate their self-efficacy to teach a particular concept using a Likert scale from 1("not confident at all") to 6("completely confident"). To investigate the sources of variation in levels of self-efficacy, the authors designed open-ended questions asking participants to describe why they feel less/more confident about certain statistical concepts. This paper discusses results from multiple U.S. public institutions of higher education.

INTRODUCTION

The preparation and development of schoolteachers to teach statistics in the United States and many other countries has been guided by recommendations from both the mathematics and statistics professional communities. In 2007, the American Statistical Association endorsed the *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) *Pre-K-12 Report* (Franklin et al., 2007), which presented a curriculum framework based on developmental levels. In addition to these guidelines, the *Mathematical Education of Teachers* (MET) II report was published (Conference Board of the Mathematical Sciences, 2012). The authors of the MET II report recommend the preparation of future schoolteachers focus on the content needed to teach statistics outlined in the Common Core State Standards (National Governors Association, 2010). The aforementioned documents have collectively served as tools to: 1) design new curriculum for future teachers, especially at the secondary level (middle grades and high school), 2) develop new professional development programs, and 3) create new agendas for research in teacher education.

Among the new foci for research is the investigation of pre-service teacher self-efficacy to teach statistics and its relation to teachers' other characteristics such as their previous experiences learning statistics and their role as a future teacher. In statistics education, only a few studies have explicitly studied teacher self-efficacy (Estrada, Batanero, & Lancaster, 2011). These initial investigations have provided some evidence that there is variation related to levels of self-efficacy as a function of statistical topics, but the explanation of this variation is not well understood. We address this problem by using new measures of self-efficacy, the Self-Efficacy to Teach Statistics (SETS) instruments (Harrell-Williams et al., 2013) to answer the following research question: *What are the sources of variation in levels of pre-service teacher efficacy to teach statistics?*

THE SETS INSTRUMENTS AND THEIR PROPERTIES

The authors began development of the SETS instruments in 2008. The process started with an extensive review of all existent self-efficacy instruments (Enochs, Smith, & Huinker, 2000; Finney & Schraw, 2003; Tschannen-Moran & Woolfolk Hoy, 2001). It was found that these prior instruments either focused in other areas such as mathematics and science or measured student (not teacher) self-efficacy (Harrell et al., 2009). Hence, the team decided to develop new instruments.

Along with 15 demographic questions, the middle school SETS instrument consists of 11 items corresponding to GAISE Level A and 15 items to GAISE Level B. The instrument has respondents rate their confidence in *teaching [specific statistics concepts to] middle school students* using a 6-point scale in which higher values correspond to higher confidence. Content validity was

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established during the first two years of the project using experts' judgment, focus groups, and multiple pilot studies (Sorto et al., 2010). Experts were college-level statistics educators, including teacher educators. Focus group and informal feedback came from both pre-service and inservice teachers.

Four large public institutions of higher education in the United States served as sources of participants (N=309) for the validity study for the middle grades SETS instrument. Harrell-Williams et al. (2014) outlines structural, substantive, and content validity evidence for the scores from the middle grade SETS instrument. Furthermore, confirmatory factor analysis results provide evidence for treating the middle grade SETS as a two-dimensional instrument aligned with levels A and B of the GAISE Pre-K-12 framework.

The high school SETS instrument was designed to contain the 26 middle grades items as well as 18 items addressing topics in GAISE Level C. This design not only includes all levels, but also allows us to: 1) validate measures at the high school level, 2) confirm the current findings about the middle grades SETS, and 3) identify variation in levels of efficacy at the upper GAISE level. Data collection for the validity study for the high school SETS instrument is underway.

VARIATION OF LEVELS OF EFFICACY

Responses from the middle school SETS validation study data collection provided evidence of variation in the levels of efficacy (Harrell-Williams et al., under review). Using Rasch modeling, topics were rank ordered by difficulty of endorsement. The topics teachers felt most confident about teaching were related mostly to GAISE Level A: creating and using tables and graphs to summarize and describe univariate data, and recognizing the existence of variability in the data collected among individuals in the same group as well as from different groups. In contrast, topics teachers felt least confident to teach were related mostly to GAISE Level B: making distributional comparisons across groups, using and interpreting measures of association, and developing a research question. Even though these results are consistent with other studies about teachers' beliefs and levels of confidence (Begg & Edwards, 1999; Watson, 2001), the source of this variation has not been explicitly studied. Some of the interviews conducted by Begg and Edwards (1999) suggest that one of the reasons could be the lack of familiarity with the terms. Although we could conjecture the possible reasons for the variation, we need to investigate possible reasons empirically with pre-service teachers.

CURRENT WORK

Data collection efforts with the high school SETS instrument are underway and are expected to be completed by the end of 2014. Multiple institutions across the United States are participating, with representation from the East, Midwest, and Southwest regions. The target population is future high school teachers who are taking or have completed at least one course in statistics.

To assess the source of variation in levels of self-efficacy, the research team designed a set of open-ended questions that ask the participants to reflect on their responses to specific items in each section of the high school SETS instrument and explain why they feel that way about teaching the statistical concepts in those items. Figure 1 shows an example open-ended question for items related to GAISE Level A. Parallel items were written to correspond to Level B and to Level C.

Open-Ended Question A:
Please review your responses to **items 1 – 11.**

a) Looking at the one or two items from **items 1 – 11** that you indicated feeling **LEAST** confident about teaching high school students, think about the reason(s) you feel this way. Use the space below (and the back of this paper, if necessary) to explain your reason(s), identifying which reason goes with which item number. If you have more than one reason, please explain as many as you can.

b) Looking at the one or two items from **items 1 – 11** that you indicated feeling **MOST** confident about teaching high school students, think about the reason(s) you feel this way. Use the space below (and the back of this paper, if necessary) to explain your reason(s), identifying which reason goes with which item. If you have more than one reason, please explain as many as you can.

Figure 1. Example of an open-ended question targeting GAISE Level A

The first wave of responses in our data collection provided some reasons for why the pre-service teachers rated themselves as less confident to teach certain tasks. These reasons include: a lack of exposure to a specific topic or using statistical software at this point in their preparation program, the length of time between completion of the SETS instrument and their most recent statistics course, a belief that teaching reasoning is more difficult than teaching computation, and concern about their ability to explain a concept effectively. Pre-service teachers were more confident about statistical topics that they: enjoyed, viewed as having relevance to students and the world in general, covered more thoroughly in their statistical coursework, saw emphasized in courses other than a statistics course (such as data collection in a psychology course), and that they have had experience with by tutoring or student teaching.

CONCLUSION

There is some evidence regarding the existence of variation in levels of confidence (Begg & Edwards, 1999; Watson, 2001) and self-efficacy (Harrell-Williams et al., under review) with respect to teaching statistics topics in K-12 mathematics classrooms. Utilizing open-ended questions asking the participants why they feel less/more confident about certain statistical concepts, we found that the reasons are of a different nature. Some relate to the level of exposure to a specific topic or experience teaching the concepts. Other reasons relate to the belief that teaching higher-order thinking is harder than teaching lower-order thinking or that some topics are more relevant than others. As a future direction of research, similar studies should be carried out in other countries.

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REFERENCES

Begg, A., & Edwards, R. (1999). Teachers' Ideas about Teaching Statistics. *Proceedings of the 1999 Combined Conference of the Australian Association for Research in Education and the New Zealand Association for Research in Education.* Melbourne: AARE & NZARE. Available at http://publications.aare.edu.au/99pap/beg99082.htm

Conference Board of the Mathematical Sciences (2012). *The Mathematical Education of Teachers II*. Providence RI and Washington DC: American Mathematical Society and Mathematical Association of America.

Enochs, L., Smith, P. L., & Huinker, D. (2000). Establishing Factorial Validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics*, *100*(4), 194-202.

Estrada, A., Batanero, C., & Lancaster, S. (2011). Teachers' Attitudes Toward Statistics. In C. Batanero, G. Burrill, & C. Reading (Eds.), *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study* (pp. 4289-4294). New York: Springer.

Finney, S. J., & Schraw, G. (2003). Self-efficacy Beliefs in College Statistics Courses. *Contemporary Educational Psychology*, *28*(2), 161-186.

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2007). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework*. Alexandria, VA: American Statistical Association.

Harrell, L. M., Pierce, R. L., Sorto, A., Murphy, T. J., & Lesser, L. (2009). On the Importance and Measurement of Pre-service Teachers' Efficacy to Teach Statistics: Results and Lessons Learned from the Development and Testing of a GAISE-based Instrument. In *Proceedings of the 2009 Joint Statistical Meetings, Section on Statistical Education* (pp. 3396-3403). Alexandria, VA: American Statistical Association.

Harrell-Williams, L. M., Sorto, M. A., Pierce, R. L., Lesser, L. M., & Murphy, T. J. (under review). Identifying Statistical Concepts Associated with High and Low Levels of Self-Efficacy to Teach Statistics to Middle Grades.

Harrell-Williams, L. M., Sorto, M. A., Pierce, R. L., Lesser, L. M., & Murphy, T. J. (2014). Validation of Scores from a Measure of Teachers' Self-efficacy to Teach Middle Grades Statistics. *Journal of Psychoeducational Assessment* [online], *32*(1), 40-50.

National Governors Association and Council of Chief State School Officers (2010). *Common Core State Standards for Mathematics. Common Core State Standards (College- and Career- Readiness Standards and K–12 Standards in English Language Arts and Math).* Washington, D.C.: National Governors Association Center for Best Practices and the Council of Chief State School Officers. http://www.corestandards.org

Sorto, M. A., Harrell, L. M., Pierce, R. L., Murphy, T. J., Enders, F. B., & Lesser, L. M. (2010). Experts' Perceptions in Linking GAISE Guidelines to the Self-Efficacy to Teach Statistics Instrument. *Proceedings of the 2010 Joint Statistical Meetings, Section on Statistical Education* (pp. 4289-4294). Alexandria, VA: American Statistical Association.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher Efficacy: Capturing an Elusive Construct. *Teaching and Teacher Education*, *17*(7), 783-805.

Watson, J. M. (2001). Profiling Teachers' Competence and Confidence to Teach Particular Mathematics Topics: The case of chance and data. *Journal of Mathematics Teacher Education*, *4*(4), 305-337.