The AMTE Research Committee[1] presents a "Connecting Research and Practice" Interview

"That's what happened to the Tape-Roll Toss task":

Connecting Research and Practice by Observing and Listening to Practitioners

An interview with:

Mary Kay Stein,
University of Pittsburgh

Margaret (Peg) Smith,
University of Pittsburgh

Victoria (Vic) Bill,
University of Pittsburgh

The Task Analysis Guide (TAG; Appendix A; Stein & Smith, 1998), Mathematical Tasks Framework (MTF; Appendix B; Stein, Grover, & Henningsen, 1996), and "5 Practices" (Appendix C; Smith & Stein, 2011) are familiar tools and frameworks to many mathematics education researchers and mathematics teacher educators. While originating in research (e.g., Stein, Grover, & Henningsen, 1996; Stein, Engle, Smith, & Hughes, 2008), these tools are

[1]AMTE 2020 Research Committee: Meghan Shaughnessy (Chair), Melissa Boston, Leslie Dietiker, Winnie Ko, Chandra Orrill, and Mary Raygoza. Article prepared by Melissa Boston, based on an interview conducted on December 18, 2019.

equally as familiar to mathematics teachers, coaches, and instructional leaders in K-12 schools. How did they become useful and accessible to practitioners? In this article, the AMTE Research Committee aims to provide insight into the development of research-practice connections by sharing an interview with Victoria (Vic) Bill, Margaret (Peg) Smith, and Mary Kay Stein. Their partnership spans over 25 years at the University of Pittsburgh's Institute for Learning (IFL), Learning Research and Development Center (LRDC), and School of Education (SOE). As a team, they have ***complementary strengths***, which they describe as Victoria Bill (Senior Mathematics Fellow at the IFL) having "both feet planted in the practitioner world," Mary Kay Stein (Senior Scientist at LRDC, Learning Sciences and Policy Professor in the SOE) having "both feet firmly planted in the research world," and Peg Smith (Senior Scientist at LRDC and Mathematics Education Professor Emerita in the SOE) having one foot in each domain and serving as the "boundary spanner."

Identifying a Research-Practice Connection

How did they decide to pursue connections to practice, and how did they identify which parts of their research would be useful to practitioners? By ***listening to practitioners***. Peg describes, "Mary Kay, I remember coming back from that NCTM meeting and having this conversation with you standing in the hallway between our two offices, and telling you… the teachers' reaction to the [research] presentation, and we started talking about how we really needed to communicate this to teachers. …I always thought of that as the pivotal moment. That's what happened first and then from there, everything else sort of emerged." In that presentation, Ed Silver (Professor, University of Michigan) was sharing key findings from the QUASAR[2]

[2] Quantitative Understanding: Amplifying Student Achievement and Reasoning (Silver & Stein, 1996)

Project-- namely, that the cognitively challenging aspects of mathematical tasks can decline as tasks are implemented during mathematics lessons. As he was talking, a teacher in the audience (a participant in the QUASAR Project), turned to Peg and exclaimed, "That's what happened to the Tape Roll Toss task!"

As expressed by Mary Kay, the team realized "we put a language on things that the teacher already knew was happening, but didn't know how to talk about, and without that language, it is…hard to move forward." Vic agreed, "the IFL hears that over and over" from teachers, coaches, and instructional leaders, "these tools describe what I knew was happening, and give me a way of talking about it. And it happens to everybody [teachers], so it's just like we found a space where,…whatever you teach, everybody causes tasks to decline. It was a wake-up call, where people were like, 'Oh that's happened to me'."

As they developed the Task Analysis Guide, Vic served as the sounding board, sending back versions that did not "speak to teachers" for additional revisions. Vic recalled, "Think how honored I felt that you were listening... coming back over and over asking me to look at something. I thought, wow they really do care... it made (the TAG) so much more *usable*." Peg described, "So it was really trying to take the characteristics of tasks and turn it into a task analysis guide that would be practical and useful, and that's where Vic, she would look at it and say, 'no, it's got to fit on one page, it's got to have bullets, this isn't going to work.'… The three of us finally negotiated the Task Analysis Guide. I don't think it's changed a word in over 20 years because once we got it, that was it."

Important Contributions to Practice

When asked what they consider the most important contributions to practice, all three identified the ***tools emerging from research***: the TAG, MTF, patterns and factors of maintenance and decline, lesson planning tool (the Thinking Through a Lesson Protocol[3] [TTLP]), and the 5-practices. Peg noted that all of these tools were created in service of supporting teachers to maintain cognitive demands: "…nothing else ever would have happened if it weren't for the MTF and TAG because, it was understanding what could happen to a task that let us to do everything else, that led to the notion of 'you got to plan more carefully,' which led us to the planning tool, which led us to the five practices that would help you organize the discussion. And organizing discussion was all about maintaining the demands of the task, so without the MTF and TAG as the underpinning, there would have been nothing to hang the rest of it on. We might not have even thought of the rest of it because it was all in service of the main idea, which is *how do you keep this task at a high level so student learning is accomplished?*" Vic agreed, "the first-year (of professional development) with the IFL, you learn about the MTF and maintenance and decline, and the TAG, and we go back to them in subsequent years." She was also quick to identify ***a larger philosophical piece*** about engaging teachers as learners and using cases to "name and generalize the particulars of teaching": "there is a bigger philosophical piece that you (Peg) brought to the IFL. We don't just take the tools, we take this idea of… engag(ing) folks as learners, we have to step out and reflect on that learning, then we analyze cases." In addition to creating tools, the team made a commitment to (as described by Peg): "illustrate these patterns from the research in a way they can serve as learning tools for teachers so that you can see both the specifics of what happened and view that as something more

[3] Smith, Bill, & Hughes (2008).

generalizable…. And that led to the purple book[4], the idea of … how cases were specific instantiations of a larger set of ideas about teaching and learning." Mary Kay added, "I want to just pay it back here to our colleague who recently passed away, Marjorie Henningsen. Marj was the first to recognize the importance of the patterns of maintenance and decline.[5] She was the first person to say, 'we have these patterns, we really should make them into cases.' And that was a big step, and it was, I think, the right step at that point in time because the cases in the purple book were so accessible."

Peg described the trajectory, "what's interesting is that we ~~started with, we~~ did a lot of work on cases, we did the three other casebooks[6] more grounded in particular content, but then we started moving to using video. The Taking Action series[7], featuring videos drawn from Vic's work in the IFL, provided different kinds of instantiations of the things we wanted teachers to think about, and then the more recent Five Practices in Practice[8] series that extend the notion of video examples even further." Within their work with narrative cases, the team progressed from writing longer cases, to thinking about how to make the cases more accessible in professional learning settings with a class or audience, to developing shorter cases and using videos. Peg described, "basically in Taking Action and 5-Practices we were trying to provide instantiations of what the effective teaching practices look like in action, so again it's not about what this particular teacher is doing, but what this represents more generally,… to serve as a broader case. It's never about, we want you to try this lesson and do it the way the teacher did it."

[4] Stein, Smith, Henningsen, & Silver (2000; 2009).
[5] See Henningsen & Stein (1997).
[6] See Smith, Silver, & Stein (2005abc).
[7] See Boston, Dillon, Smith, & Miller (2017); Huinker & Bill (2017); Smith, Steele, & Raith (2017).
[8] For example, Smith & Sherin (2019); Smith, Bill, & Sherin (2020); Smith, Steele, & Sherin (2020).

Making the Work Accessible to Practitioners

Mary Kay contended that the work is usable by practitioners (at a variety of levels) not just because the team listened to teachers, but because of the time spent carefully ***observing teaching and learning***—watching mathematics lessons and seeing patterns, and the research and resulting tools grew out of what was happening in classrooms. They observed classrooms, developed frameworks, put the frameworks to use in practice, and sought teachers' input. Mary Kay noted, while the work could have remained in research, they wanted to communicate with teachers: "the way QUASAR operated, we worked alongside teachers." She described how she and Marj Henningsen presented the MTF at an invited talk at AMTE (1997 in Washington DC), which led to NCTM publications in MTMS (Stein and Smith, 1998; Smith and Stein, 1998). She explained that the team committed to ***publish in outlets accessible to practitioners***: "people who do classroom research don't always take the next step to communicate it to teachers in the way that we came to be committed to doing, and if it had remained the article in AERJ[9] and Stein and Lane (1996), it's pretty clear it never would have had the impact that the work has had." Peg agreed, adding, "an article in the best journal … what does it mean if you are writing *about* practice? Does that really have the impact, if you are talking to other researchers? What is really making a difference in what teachers do day to day? If we really want to influence practice and not just other researchers, then we have to think about *what are the outlets* and *who are the audiences*." She acknowledged she was supported by her institution and valued for publishing in

[9] Stein, Grover, & Henningsen (1996).

practitioner outlets, whereas in some Universities, "practitioner publications as opposed to research… is one of those thorny problems."

Vic underscored the importance of access for practitioners: "to get research to practice, we needed the research to be published, to have published materials to use. Why doesn't some work have a similar impact on practice? Was it published any place where a teacher would have read it? Were they working with people that had one foot in the teaching world? Did they put practical examples - educators speak with examples - or cases linking research and practice?" Some examples of how the team's research evolved into tools for teachers are shown in Figure 1.

Tool or Framework	Research Publications	Practitioner Publications
TAG, MTF, Factors and patterns of maintenance and decline	• Stein, Grover, and Henningsen (1996) • Stein and Lane (1996) • Henningsen & Stein (1997)	• Stein and Smith (1998); Smith and Stein (1998) • Stein, Smith, Henningsen and Silver (2000; 2009) • Smith, Stein, and Silver (2005)
Five Practices	• Stein, Engle, Smith, and Hughes (2008)	• Smith, Hughes, Engle, and Stein (2009) • Smith and Stein (2011) • Smith and Sherin (2019) • Smith, Steele, and Sherin (2020) • Smith, Bill, and Sherin (2020)

Figure 1. Examples of Research and Practitioner Publications.

The body of work reaches different layers of practitioners-- teachers, mathematics teacher educators, professional development providers, coaches, instructional leaders, and administrators. In fact, the "five practices" arose from a setting with a mathematics teacher educator (Peg) as the practitioner. The research team noticed Peg's moves in facilitating discussions of mathematics tasks during a content-focused mathematics methods course. They codified her moves, and first published the work in a research article (Stein, Engle, Smith, & Hughes, 2008), then an article in *Mathematics Teaching in the Middle School* (Smith, Hughes, Engle, & Stein, 2009), and then in the "5 Practices" book (Smith & Stein 2011), and most recently, in the "5 Practices in Practice" series (Smith, Bill & Sherin, 2020; Smith & Sherin 2019, Smith, Steele, & Sherin, 2020).

Vic explained, "we the practitioners, the IFL, we needed you to codify the practices and to write the books. It gives the work credibility." She added that she sought out research (and Peg) to deepen and enrich the IFL's work with schools: "I needed her insights, her voice, I needed her to push our thinking and ask questions and keep linking to the research….That link to the researchers is so critical in the practitioner space… we have these smart research folks, let's create these partnerships and get assistance. I've been afforded that, so how do we get other educators in the mindset that they have the right and responsibility to make those kind of connections?"

Support from Professional Organizations

In what ways can professional organizations support and foster connections between research and practice? Mary Kay described, "We (Mary Kay and Marj Henningsen) actually presented the Math Tasks Framework at the very first AMTE meeting ever (1996), …that was part of an NCTM meeting, when the organization was still in its infancy, and then we went to

AMTE the next year (1997) in Washington DC. … (T)hey provided us with a forum for talking about the work, and people seemed to embrace it, because a lot of those people then ended up using the 1998 articles and the purple book in their methods class and PD work, so it was that audience who was going to go and use this stuff in ways that would change the way they prepared future teachers." The books and articles written for practitioners evolved from talks, papers, and presentations that seemed to connect with teachers and colleagues. Professional organizations such as AMTE, NCTM and NCSM provided a platform and publishing outlet to share the ideas through conferences, practitioner journals, and serving as co-publishers for books.

Ongoing Influence of their Work

When asked about the ongoing influence of their work, the team began by circling back and acknowledging the colleagues who supported the original work: Ed Silver, Marjorie Henningsen, and Walter Doyle. Mary Kay described, "Walter Doyle had this big idea that tasks are not the same when they appear in books versus when you set them up, versus when you work on them[10]. We owe a big intellectual debt to Walter. I don't think he even knew, how the math education world has been so touched by his idea." In continuing to move the work forward, she adds, "my former graduate student (Miray Tekkumru-Kisa) has come up with a task analysis guide in science[11]. Recently she and I wrote a paper with Walter Doyle[12] in which we explore the durability of the construct of a task to this day."

[10] Doyle (1998).
[11] Tekkumru Kisa, Stein, & Schunn (2015).
[12] Tekkumru-Kisa, Stein, & Doyle (2020).

Mary Kay adds, “the math task framework and cognitive demand, it is foundational for the work that came after that and it has influenced not just teachers but hundreds of graduate students. Not only at Pitt, but when Ed (Silver) moved to Michigan and started having graduate students read our work, that was one of the places of explosion of more and more people being exposed to our work. I think it has served as the backbone for a lot of dissertations.” Peg also indicated how the planning tool (TTLP) and 5-practices have influenced ways people think about teaching and learning in other content areas, such as the “5 Practices in Science” (Cartier, Smith, Stein, & Ross, 2013). She noted how the work has generated classroom observation tools, using the example of the Instructional Quality Assessment (IQA) in Mathematics (Boston, 2012) as a research tool for “studying what teachers learn or improve from professional development, …the influence professional development has on teacher's ability to maintain the demands of the task,” and as a practitioner tool (Boston, Candela, & Dixon 2019) for “principals and teachers, as a way to think about and reflect on their own practice.” Mary Kay added that tools such as the IQA have “allowed the work to go to scale.”

Closing Thoughts

In closing, this body of work has been successful in practice primarily because, as summarized by Mary Kay, “It’s a robust construct, cognitive demand.” According to Peg, “the idea that a task changes from when you pick it up and introduce it to when kids actually work on it is just a profound idea,… so simple yet so deep that it changes people's whole view about how they think about teaching and learning.”

References

Boston, M. D. (2012). Assessing the quality of mathematics instruction. *Elementary School Journal, 113*, 76-104.

Boston, M.D., Candela, A.G., & Dixon, J.K. (2019). *Making Sense of Mathematics for Teaching to Inform Instructional Quality*. Solution Tree: Bloomington, IN.

Boston, M., Dillon, F. Smith, M.S., Miller, S. (2017). *Taking Action: Implementing the Effective Mathematics Teaching Practices Grades 9-12*. National Council of Teachers of Mathematics: Reston, VA.

Cartier, J. L., Smith, M. S., Stein, M. K., & Ross, D. K. (2013). *5 Practices for Orchestrating Productive Task-based Discussions in Science*. National Council of Teachers of Mathematics: Reston, VA.

Doyle, W. (1988). Work in mathematics classes: The context of students' thinking during instruction. *Educational Psychologist, 23*(2), 167-180.

Henningsen, M. & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for Research in Mathematics Education, 28*(5), 524-549.

Huinker, D., & Bill, V. (2017). *Taking Action: Implementing Effective Mathematics Teaching Practices in K-grade 5.* National Council of Teachers of Mathematics: Reston, VA.

Tekkumru-Kisa, M., Stein, M. K., & Schunn, C. (2015). A framework for analyzing cognitive demand and content-practices integration: Task analysis guide in science. *Journal of Research in Science Teaching, 52*(5), 659-685.

Silver, E. A., & Stein, M. K. (1996). The QUASAR project: The "revolution of the possible" in mathematics instructional reform in urban middle schools. *Urban Education, 30*(4), 476-521.

Smith, M. S., Bill, V., & Sherin, M. G. (2020). *The Five Practices in Practice: Successfully Orchestrating Mathematics Discussions in Your Elementary Classroom*. Corwin Press and National Council of Teachers of Mathematics: Reston, VA.

Smith, M. S., Hughes, E. K., Engle, R. A., & Stein, M. K. (2009). Orchestrating discussions. *Mathematics Teaching in the Middle School, 14*(9), 548-556.

Smith, M. S., & Sherin, M. G. (2019). *The 5 Practices in Practice: Successfully Orchestrating Mathematical Discussion in Your Middle School Classroom*. Corwin Press and National Council of Teachers of Mathematics: Reston, VA.

Smith, M. S., Steele, M. D., & Sherin, M. G. (2020). *The Five Practices in Practice: Successfully Orchestrating Mathematics Discussions in Your High School Classroom.* Corwin Press and National Council of Teachers of Mathematics: Reston, VA.

Smith, M. S., Silver, E. A., & Stein, M. K. (with Boston, M., Henningsen, M., & Hillen, A. F.) (2005a). Improving Instruction in Ratio and Proportion: Using Cases to Transform Mathematics Teaching and Learning, Volume 1. Teacher's College Press: New York.

Smith, M. S., Silver, E. A., & Stein, M. K. (with Boston, M., & Henningsen, M.) (2005b). Improving Instruction in Geometry and Measurement: Using Cases to Transform Mathematics Teaching and Learning, Volume 3. Teacher's College Press: New York.

Smith, M. S., Silver, E. A., & Stein, M. K. (with Henningsen, M., Boston, M., & Hughes, E. (2005c). Improving Instruction in Algebra: Using Cases to Transform Mathematics Teaching and Learning, Volume 2. Teacher's College Press: New York.

Smith, M. S., & Stein M. K. (2011/2018). 5 Practices for Orchestrating Productive Mathematics Discussions. National Council of Teachers of Mathematics: Reston, VA.

Smith, M. S., Steele, M. D., & Raith, M. L. (2017). *Taking Action: Implementing Effective Mathematics Teaching Practices in Grades 6-8*. National Council of Teachers of Mathematics: Reston, VA.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning, 10*(4), 313-340.

Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning, 10*(4), 313-340.

Stein, M. K., Grover, B., & Henningsen, M. (1996) Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal, 33*(2), 455-488.

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation, 2*, 50-80.

Stein, M. K., & Smith, M. S. (1998). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School, 3*(4), 268-275.

Stein, M. K., Smith, M. S., Henningsen, M., & Silver, E. A. (2000, 2009). *Implementing Standards-Based Mathematics Instruction: A Casebook for Professional Development*. New York: Teachers College Press.

Tekkumru-Kisa, M., Stein, M.K, & Doyle, W. (in press). Theory and research on tasks revisited: Tasks as the context of students' thinking in the era of ambitious reforms. *Educational Researcher.*

Appendix A

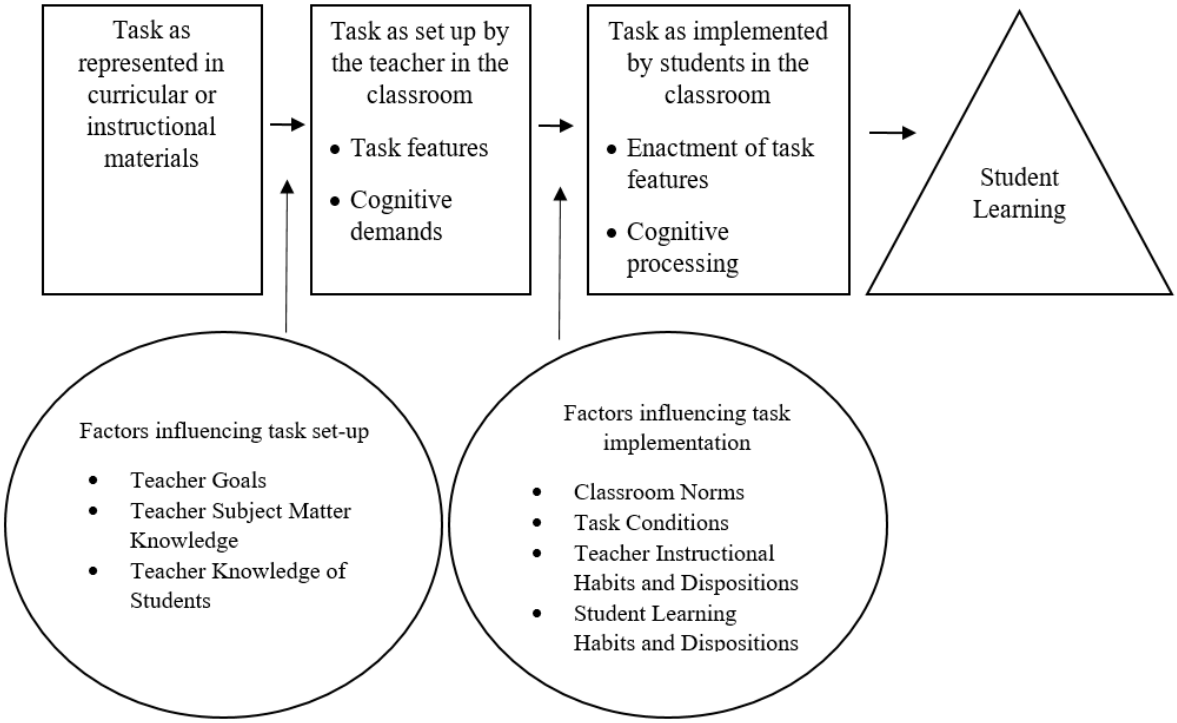
The Task Analysis Guide (TAG; Smith & Stein, 1998, p. 348)

These characteristics are derived from the work of Doyle on academic tasks (1988), Resnick on high-level thinking skills (1987), and from the examination and categorization of hundreds of tasks used in QUASAR classrooms (Stein, Grover, & Henningsen, 1996; Stein, Lane, & Silver, 1996).

Lower-Level Demands	Higher-Level Demands
Memorization Tasks • Involves either producing previously learned facts, rules, formulae, or definitions OR committing facts, rules, formulae, or definitions to memory. • Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure. • Are not ambiguous – such tasks involve exact reproduction of previously seen material and what is to be reproduced is clearly and directly stated. • Have no connection to the concepts or meaning that underlie the facts, rules, formulae, or definitions being learned or reproduced.	Procedures With Connections Tasks • Focus students' attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas. • Suggest pathways to follow (explicitly or implicitly) that are broad general procedures that have close connections to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts. • Usually are represented in multiple ways (e.g., visual diagrams, manipulatives, symbols, problem situations). Making connections among multiple representations helps to develop meaning. • Require some degree of cognitive effort. Although general procedures may be followed, they cannot be followed mindlessly. Students need to engage with the conceptual ideas that underlie the procedures in order to successfully complete the task and develop understanding.
Procedures Without Connections Tasks • Are algorithmic. Use of the procedure is either specifically called for or its use is evident based on prior instruction, experience, or placement of the task. • Require limited cognitive demand for successful completion. There is little ambiguity about what needs to be done and how to do it. • Have no connection to the concepts or meaning that underlie the procedure being used. • Are focused on producing correct answers rather than developing mathematical understanding. • Require no explanations, or explanations that focus solely on describing the procedure that was used.	Doing Mathematics Tasks • Requires complex and non-algorithmic thinking (i.e., there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, task instructions, or a worked-out example). • Requires students to explore and to understand the nature of mathematical concepts, processes, or relationships. • Demands self-monitoring or self-regulation of one's own cognitive processes. • Requires students to access relevant knowledge and experiences and make appropriate use of them in working through the task. • Requires students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions. • Requires considerable cognitive effort and may involve some level of anxiety for the student due to the unpredictable nature of the solution process required.

Appendix B

The Mathematical Task Framework (MTF; Adapted from Stein, Grover, and Henningsen, 1996)



Appendix C

The 5 Practices (Adapted from Smith & Stein, 2011, p. 8)

- Practice 0: **Setting goals and selecting tasks (**added in Smith & Stein, 2018)
- Practice 1: **Anticipating** likely student responses to challenging mathematical tasks.
- Practice 2: **Monitoring** students' actual responses to the tasks (while students work on the tasks in pairs or small groups).
- Practice 3: **Selecting** particular students to present their mathematical work during the whole-class discussion.
- Practice 4: **Sequencing** the student responses that will be displayed in a specific order.
- Practice 5: **Connecting** different students' responses and connecting the responses to key mathematical ideas.