A recently released AAC&U report stated that over seventy-five percent of surveyed employers want a greater emphasis on problem-solving skills in college. The Partnership for 21st Century Skills reported that only twenty-eight percent of employers classify college graduates’ problem solving as "excellent." Greater knowledge and cognitive skills are useful for addressing these issues but they are not sufficient. A student solving a problem also needs to employ metacognitive and self-regulation skills— a student tries different approaches, evaluates each and maybe creates new ones when problem solving. Throughout the activity, the learner is best served by constantly monitoring her work, which allows her to identify and correct errors before the conclusion.

To help students improve their self-monitoring skills, we have shifted the focus of several courses to the problem-solving process, rather than the refined end product of problem-solving—written solutions. Students and instructors solve problems using a think-aloud protocol whereby they articulate their thought-process. Through these activities students see the role of planning, monitoring and adjusting their work as they solve complex, real-world problems.

To facilitate learning, the think-alouds are recorded using Livescribe smartpens, which capture the penstrokes as well as what the recorder says. Once uploaded to the Internet, users see an animation of the written work that displays the writing in real time with synchronized audio. These recordings can be paused, rewound, and advanced to key moments in the problem-solving process.

The instructors have introduced assignments and in-class activities that utilize recorded think-alouds. To study the effectiveness of the recordings, three different implementations have been tested. In the first, Modeling, instructors create recordings that serve as extra worked examples. In Apprenticing, students view and analyze student-created recordings. Among these recordings are examples of expert-like as well as novice problem solving. In the final implementation, Scaffolding, students record and analyze their own problem solutions as well as their classmates’.

Over the course of this NSF-funded project, instructors in chemistry, mathematics, physics and teacher preparation courses have employed different implementations each semester. This has allowed us to make comparisons between the implementations while controlling for instructor differences. Changes in students’ problem-solving skills, self-efficacy, and beliefs were assessed with pre/post surveys, measures of problem-solving skills, and scores on content knowledge inventories. Results of these assessments as well as sample class activities for each of the three implementations will be presented.
Problem solving is widely considered one of the most important sets of skills for success in all science, technology, engineering and mathematics (STEM) courses, yet many students struggle to solve real-world problems. Too often teachers and textbooks portray problem solving as a collection of algorithms and heuristics, which inadequately prepare students. Textbook examples do not capture the process of problem solving as they only present polished, error-free solutions, not the thinking that lead to them.

Despite the desire to improve students’ problem-solving skills, there is a lack of instructional materials and methods that improve students’ ability to plan, monitor and adjust their thinking within a problem-solving context. Only with these self-regulation skills can students solve the challenging real-world problems that they will face in their STEM careers. As part of an NSF-funded project, the workshop facilitators have spent the last two years developing materials, mastering technology, and studying how students solve problems. Central to the project, and this workshop, are the questions: Can students, who might otherwise struggle in a STEM course, improve their problem-solving skills? Can improvement in problem-solving skills be accurately measured within the context of a STEM course?

To capture the problem-solving process, for formative and summative assessment, students are instructed to verbalize their thought process in the form of a “think-aloud.” This makes what is essentially an internal thought process explicit, allowing improved feedback to the students. This instruction cycle follows from research that has previously shown that think-alouds can improve problem-solving skills. The feedback, and assessment focuses on students’ self-regulation or self-monitoring as they solve mathematical and scientific problems.

Think-alouds are recorded using innovative, easy to use technology- Livescribe Pulse smartpens, which are ballpoint pens with embedded computers and microphones. When used with Livescribe Dot paper, a smartpen records and synchronizes pen strokes and audio to create a “pencast,” which can be uploaded to the Internet or emailed between classmates. These recordings allow the viewer to follow the recorder’s process and self-monitoring much more than in a typical static, written solution. By exchanging these recordings, students and faculty can engage in asynchronous collaboration among outside of the class. The recorded think-alouds, and subsequent analysis, then also form the bulk of the project’s assessment data.

In this workshop the presenters will share their experience in incorporating think-aloud components into their courses as well as the results from those courses. Participants will learn how to use Livescribe smartpens, incorporate think-alouds their classes, and to assess the effectiveness of think-aloud-based activities.
The multidisciplinary nature of the project team (faculty from chemistry, education, mathematics and physics) has resulted in more effective instructional materials and robust research findings than could not have been achieved with a single disciplinary perspective. Because of the team’s diverse background, the facilitators are mindful of participants’ different perspectives and have crafted the workshop to be engaging and informative for participants from any discipline. The team also has experience crafting and facilitating professional development workshops for STEM instructors at both the collegiate and high school levels.

Participants in this session will:
(1) Discuss how to design problem-solving activities that incorporate think-alouds especially in science, technology, engineering and mathematics (STEM) classes
(2) Create pencasts (think-alouds) using a Livescribe pen,
(3) Assess the quality and effectiveness of a previously recorded pencast using a rubric to measure problem solving skills that has been developed by the presenters
(4) Learn about additional resources including a searchable database of think-alouds in STEM fields and teacher preparation that is being developed by the presenters.

Relevant Bibliographic Citations:
3. G. Pólya, How to Solve It, Garden City, NY: Doubleday (1957)