

Think-Alouds as Instructional and Assessment Methods

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Motivation

- Students who are focused only on the formula and how to do the problem without wanting to know how to think through the problem.
- Students think memorization is an effective way to solve complex problems and have difficulties when they are presented with new, related problems.
- Students solving problems by attempting to mimic text book examples where mistakes are not valued or illustrated.
- K12 teachers who only know how to teach math/science problem solving as a linear, step-by-step, process that does not mirror what mathematicians and scientists do when solving challenging and real problems.

Context

- Physics for life science majors.
- First semester course which covers classical mechanics and some fluids and thermo.
- Sections have 20-30 students each.
- Class meets 150 min/ week for “lecture” and 110 min/ week for lab.

- Average pre-instruction scores:
 - Force Concept Inventory = 8.0 ± 4.0
 - “Lawson Test” = $71 \pm 16\%$

D. Hestenes, M. Wells, and G. Swackhamer, “Force concept inventory,” *Phys. Teach.* **30**, 141–158 (1992).

A. E. Lawson, “The development & validation of a classroom test of formal reasoning,” *J. Res. Sci. Teach.* **15**, 11–24 (1978).

Think-alouds

- Think-alouds can help to make the internal problem-solving process explicit.
- Berardi-Coletta showed that with targeted instruction, verbalization led to more effective problem-solving.
- Verbalization helps students become aware of their thought process, thereby improving their ability to identify and correct own errors.

Broad question

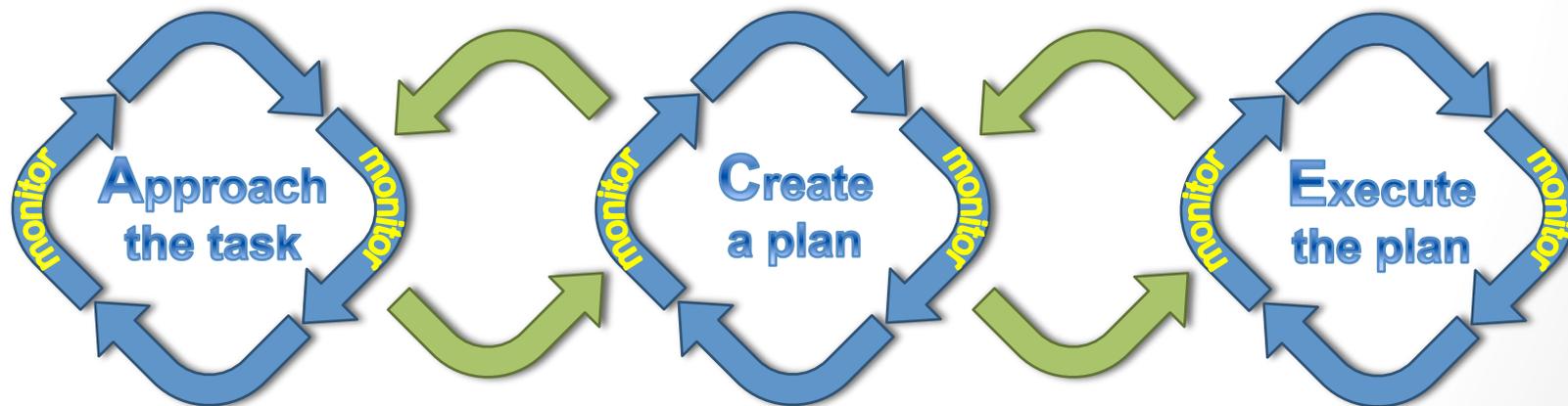
Can we observe improvements in STEM problem solving by using think alouds?

Tried two different implementations:

1. Students view and analyze previously recorded think-alouds
2. In addition to viewing others' think-alouds, students record their own.

ACE Problem Solving Process

- *Analyze the task*: interpret and understand what is provided in the task.
- *Create a plan*: connect the given information and goal with models/concepts/relationships
- *Execute the plan*: follow the plan until the goal is attained
- Monitoring one's progress throughout



Smartpens

- When used with Livescribe Dot paper, a smartpen records and synchronizes pen strokes and audio to create a “pencast.”
- Recorded pencasts can be transferred to a computer via a USB connection.
- From there, the recordings can be emailed or posted online.



Sample pencasts



Did implementation of think-alouds impact students' performance?

- The FCI normalized gains of the classes where students created (and viewed) think-alouds were nearly 50% higher than the prior years when those activities were not used (0.55 versus 0.37).

Did students' views of their own problem-solving process change?

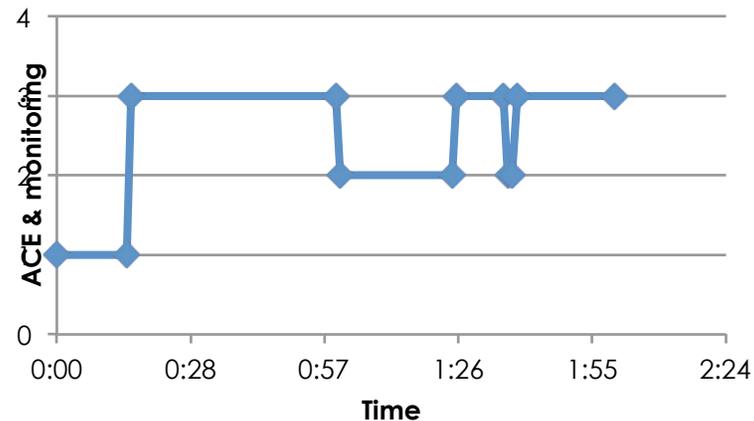
- Students completed a 60-item survey related to problem solving and overall course motivation and self-efficacy pre and post-instruction.
- Improvements were seen on the problem solving motivation, planning and adjusting clusters, but a deterioration was seen in the monitoring cluster.
 - Planning
 - I find that I'm most successful at solving word problems if I quickly jump in and start working with some equations.

Do we see changes in students' self-monitoring in problem-solving?

- Coding think-alouds for frequency and type of self-monitoring during a solution.
 - *Checking for external consistency*
 - *Checking for internal consistency*
 - *Checking for completeness*
 - *Considering alternatives*
 - *Looking forward*

Do we see changes how students utilize the three-step process?

- Creating timelines for recordings that show when a solver is engaged in *Analyzing the problem*, *Creating a plan* or *Executing the plan*.



Can we isolate *when* and *why* any changes occurred in the students?

- I actually did enjoy making pencasts. I thought that it greatly improved my problem-solving strategies and **helped organize my thoughts** a lot more than they would've been without pencasts.
- Making pen casts was helpful in that it made me really question my methods when solving problems. This questioning was often frustrating (to say the least), but it helped me learn how to **solve problems in a way that was much less passive**.
- **It made me slow down** and really try to understand the problem long before I simply grab numbers and equations and try to plug them all into each other.
- I learned to take several steps in order to help me be successful in solving the problem. **I made sure to ask myself right off the bat WHAT exactly it was that I was trying to find out** in the problem, and then make a plan how to get there instead of panicking and letting my random thoughts run wild on the paper.

One possible case study

- On the first three in-class tests, Isaac's scores were 18-24% below the class average.

*At the beginning of the semester **I was quite skeptical of the livescribe pen** and how following a few simple guidelines/ approaches to problem solving could change the way I think....**I stubbornly have to admit that the whole process took much longer than I had anticipated due to my unwillingness to embrace the pen as well as the process of talking out my actions....** It took almost the whole semester but I have finally come to a point **where I find myself automatically dictating my comprehension process to prove to myself that I truly understand what is happening** and the best method to approach a problem while utilizing key concepts.*

- The fourth test, where he reported that he was more aware of his thinking and would engage in metacognitive thinking, was only 6 points below the class average.
- On a post-instruction survey Isaac reported that his test anxiety was eliminated.

Help!!! (please)

- Thoughts on how I can focus my questions and data collection?
 - What suggestions are there for running a control section?
 - How can I isolate any possible effects of the think-alouds from other alterations to the course?
 - Is it possible to distinguish between a lack of verbalization and a self-monitoring?

Thanks!!!

- For more information on our project visit:
<<http://www.pensproject.com>>
- We'd love more feedback, and possible partners!
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