Problem-solving Examples with Narration for Students (PENS)

Jeff Phillips (Physics), Kathy Clemmer (Education), Jeremy McCallum (Chemistry)
& Thomas Zachariah (Mathematics)
Loyola Marymount University

Introduction

The Problem-solving Examples with Narration for Students (PENS) project is creating and assessing instructional materials that target one of the central skills required for success in the STEM fields: problem-solving. Instead of focusing solely on the refined end product of problem-solving, written solutions, students are instructed on how to focus explicitly on the problem solving process, with particular attention paid to self-regulation. To make what is essentially an internal thought process explicit, students and instructors record think-alouds that are then included in mathematics, chemistry, physics and teacher preparation courses.

Context

PENS materials have thus far been implemented in introductory physics for life science majors, organic chemsitry, advanced probability and statistics, linear algebra and a methods course for pre-service teachers. All courses have been taught at LMU, a four-year, private, Catholic, comprehensive Master's institution, where 34% of the undergradaute student population is from groups that are traditionally underrepresented in the STEM workforce.

Different implementations have been tried in each of the disciplines over the past two years. Some have solely provided expert-crated pencast solutions (step1), others have asked students to view and analyze novice-created pencasts (step2) and finally a third variation had students recording their own pencasts (step 3) .

Technology

Think-alouds are recorded using Livescribe smartpens, in which there are embedded computers and microphones. When used with Livescribe Dot paper, a pen 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.

Activities

Step 1

Students are shown expert created solutions that have been recorded using a think-aloud protocol. These solutions offer students a more complete and dynamic model than what is found in textbooks, but are still lacking in significant self-regulation and error correction. Generally, there are no specific assignments connected to these recordings.

Step 2

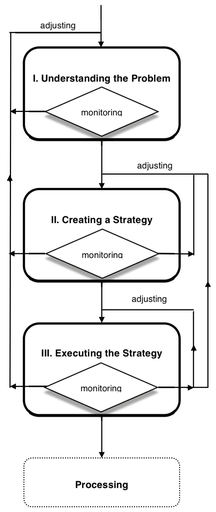
Homework assignments ask students to view and critique previously recorded think-aloud pencasts, which typically containt content and/ or problem-solving errors. Students are asked to provide feedback to the recorder as well as reflect on the recorded solution's similarities and differences to their own thought process.

Step 3

In addition to the Step 2-type activities, students record all of their practice using Livescribe smartpens and a think-aloud protocol. The pens facilitated asynchronous discussions outside of class as students can email the instructor any solution with which they were struggling. In-class activities included instruciton and feedback on performing a think-aloud.

Problem-solving Model

Activities encourage students to self-monitor/ self-regulate throughout their process. At each step of the Polya-like process, students are taught to ask themselves whether or not they are prepared to go to the next step, or if there is an error or shortcoming. This leads to an iterative process where students may revisit each step multiple times. This iterative approach is significantly different than the one used in typical textbook examples.



Pre-service Teachers

Teacher candidates compare their own approaches and strategies to physics and algebra 2 questions. They also analyze recorded solutions; quantifying the time a student spends on understanding the question, creating and executing a strategy as well as the amount and type of monitoring. These recordings give the candidates insights into the challenges they will soon face in the classroom.

Case Study from Physics

Isaac had a Lawson Test score that indicated a lack of formal operational thinking & a GPA that was 0.3 lower than the class average. On the first three in-class tests, his 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 pre/ post-instruction survey, Isaac shifted his responses from one that showed no self-regulation (or valuing of self-regulation) in problem solving (continuously planning, monitoring and adjusting one's thinking) to a more expert-like position. On the same survey, he reported that his test anxiety also was eliminated.

Class Average Results

Chemsitry

In Fall 2012, two Organic Chemistry sections were taught by the same instructor. The courses were identical, except for the homework assignments. One section completed questions within an online homework system and the other implemented PENS-step 2.

Among those students who appear to be transitional thinkers, rather than formal operational, those in the section that viewed and analyzed pencast recordings, scored on average 2% higher on all of their in-class tests and final exam.

Physics

The class average Force Concept Inventory normalized gains for sections implementing PENS instructional methods (2011 & 2012) have been higher than prior years without think-aloud activities (2008-2010): 0.55 vs 0.37.

Conclusions

- The Livescribe pens make it easy to record, view and analyze student think-alouds. These recordings are the basis for various class activities, which appear to be helping some students engage in self-regualted problem-solving.
- We are in the process of coding the think-alouds pencasts with the hope of quantifiying students' problem-solving proficiency. However, we are struggling with inter-rater reliability as we attempt to assess self-regulation in problem solving.
- We are collecting the recordings in a searchable database that will be available to instructors and trainers of K12 teachers.

http://myweb.lmu.edu/jphillips/PENS

Work supported by NSF
TUES-1044062