An Online Tool for Organizing Self-Regulatory Learning and Promoting Metacognitive Engagement in Problem-Solving

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The Challenge

↗ How can we teach students scientific problem-solving?
↗ How can we motivate students to adopt and sustain reflective practices?
↗ How can we instill these practices beyond the classroom?

Background & Setting

↗ Herman Gordon teaches The Art of Scientific Discovery (AoSD) for undergraduate & graduate students at the University of Arizona.
↗ AoSD teaches scientific problem solving through puzzle based learning.
↗ Motivations for the course:
  ◦ Science & medical practice require:
    ◊ Creative thinking
    ◊ Reflective practice
    ◊ Continuing innovation
  ◦ Rote methods have become routine in K-20 education
  ◦ The Disconnect: How students are taught ≠ Thinkers we need to "produce" (National Research Council, 2005; Falkner, Sooriamurthi & Michaelewicz, 2010)

The Pedagogy:
Structured Problem-Solving & Peer Learning

↗ **Structured Problem-Solving**
  ◦ Organizes thinking
  ◦ Encourages Reflection
  ◦ Locates learner within the process
  (Polya, 1957; Platt, 1962; Falkner, et al. 2010)

↗ **Metacognitive Engagement**
  (Daniels, 2004; Hume, 2009)

↗ **Self-Regulatory Learning**
  (Spear-Ellinwood, 2011; Rivers, 2001; Schön, 1987; Vygotsky, 1978)

↗ **Zones of Proximal & Distal Development**
  (Cole, 1996; Spear-Ellinwood, 2011; Vygotsky, 1978)

↗ **Social Networks Support Learning**
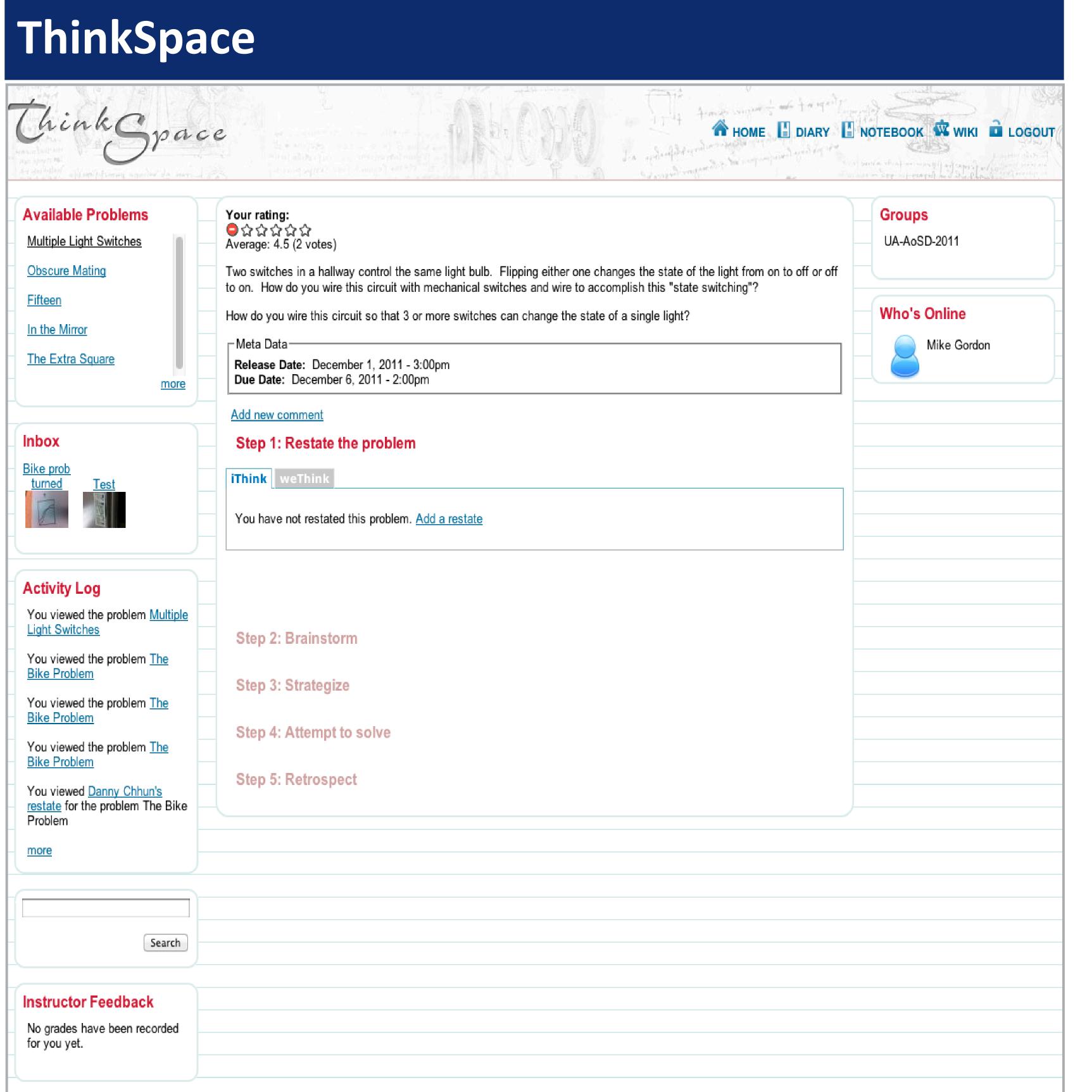 (Engeström, 1999, 2000, 2004)

Strategic Guidance
(Tools, Resources, & People)

Self-Regulatory Learning

Foundation
Social Network Supports Self-Regulatory Learning, Collaboration & Distribution of Knowledge & Practices

Learner

Problem-Solver

Progress

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The Proposed Solution

↗ **ThinkSpace online tool**
  ◦ Uses a 5-step structure for problem-solving
  ◦ Renders thinking visible to self, peers and instructors
  ◦ Offers metacognitive aids, e.g., Wiki-based help, strategic guidance questions at each step, access to self and peer thinking, and instructor feedback
  ◦ Automatically records all student activity for data mining.

Step 1 Define the Problem
Step 2 Brainstorm
Step 3 Strategize
Step 4 Attempt
Step 5 Retrospect

Problem-Solving Structure
Aligned with Self-Regulatory Learning

ThinkSpace

Findings

↗ **Intensified engagement**
  ◦ Mean 50 pgs/student
  ◦ Thought Trails 4.6x minimal effort
  ◦ Mean Peer Views 17x/problem
  ◦ Mean 42% Pre-Retro Updates preceded by Peer Views (SE=14%)

↗ **Sustained Engagement**
  ◦ Within problem: Beyond the minimum
  ◦ Beyond the problem: Post-Retrospect Activity
    ◊ Activity, 72% of problems
    ◊ Updates, 15%
    ◊ 23% of Updates are Post-Retrospect
  ◦ Enduring effort over 16 weeks
    ◊ Mean Activity Index (AI) for course, 2.4 (SE=.5)

↗ **Leveraging Peer Thinking to Advance Their Own**
  ◦ 91% of Views are Peer Views
  ◦ 40% of Updates are Preceded by Peer Views
  ◦ Median 42% view peers before next step

Post-Retrospect updates 3%
Inserts 18%
Wiki Views 4%
Peer Views 65%
Pre-Retrospect Updates 8%
Self Views 2%
Retrospect 15%
Restate 12%
Attempt 6%
Strategize 33%
Brainstorm 34%

What are students looking at?

Data Mining: Thought Trails

AI=0 Fiona - Week 4, Problem 5
AI=1 Rory - Week 10, Problem 15
AI=2 Carrie - Week 5, Problem 8
AI=3 Clare - Week 12, Problem 17
AI=4 Decio - Week 8, Problem 10
AI=5 Harmon - Week 4, Problem 6

Restate Brainstorm Strategize Attempt Retrospect

Insert
Update
PeerView
Self View
PeerView (PriorProb)
Post-Retrospect Activity
Final Step
Begins subsequent problem
Continues subsequent problem
Working other problems

AI=Activity Index, Variation in type of activity

↗ **Evidence of Metacognition**
  ◦ Quality of entries → reflective writing
  ◦ ThinkSpace as mirror → Reviewing prior self-entries
  ◦ ThinkSpace as Social Network → Consulting peer ideas
  ◦ Evaluative thinking → Reviewing after completion

Student Quotes

↗ **Acceptance of the Tool**
"I can proudly say the ThinkSpace changed me for the better as it forced you to really dissect the problem before you tackled it, which is not something I did before this class. ... I think of the ThinkSpace as thinking training." [TF]

↗ **Acceptance of the Structure** "...it helps break down the problem into little sections so that I am not overwhelmed." [DC]

↗ **Applying it Forward** "What this class has forced me to do is to cut out the internet and replace the search bar with my brain. This has been a very difficult thing to do" [KH]

Sustained Engagement

22 Problems over 16 weeks

— Mean Activity Index by problem (% of 5 activities)
— Mean Inclination to View Peers before Next Step
— Mean %age of Updates per problem
— Mean %age of Total Views per problem

ThinkSpace Value

↗ **ThinkSpace**
  ◦ Makes explicit the structure for problem-solving
  ◦ Establishes social network that extends classroom collaborative thinking
  ◦ Makes student thinking visible for metacognitive reflection
  ◦ Supports instructor feedback
  ◦ Automatically records student activities for data mining and research
  ◦ Provides strategic guidance for developing problem-solving abilites

↗ **Students Adopted Problem-Solving Practices & Leveraged Peer Thinking**
  ◦ Students adopted the structure, tool and practices for problem-solving
  ◦ Students leveraged peer thinking to advance their own
  ◦ Students engaged in a variety of activity throughout the course
  ◦ Student entries and navigation patterns evidenced metacognition
  ◦ Students were motivated to apply problem-solving structure & practices to new situations

ThinkSpace Potential

↗ **ThinkSpace can be adapted** to problem-solving in other contexts. In particular we have modified the 5-step structure to accommodate the progressive release format of Case Based Instruction and medical discourse. (See Poster by St. John, et al.)

Acknowledgements