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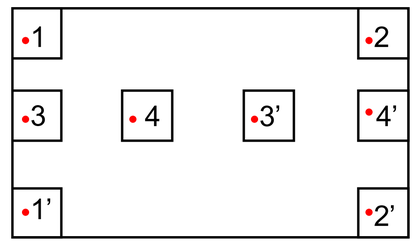
TEACHING & LEARNING SUMMIT 2016



Find or Prove

(a) find a way to connect each number to its prime (1 to 1'; 2 to 2' etc) by a continuous line that doesn't intersect with other such lines nor touch any other contact point or (b) to show that it is impossible.

Carnegie Mellon University

Puzzle-based Learning

Introducing Critical Thinking and Problem Solving

Metacognition: Puzzles as a Means to an End

"Both the solver of a puzzle and a technical innovator must be able to identify essential elements in a situation that is initially ill-defined. It is rarely clear what type of reasoning is required or what the precise limits of the problem are. The solver must nonetheless persist until it is possible to bring the analysis to a timely and successful conclusion"

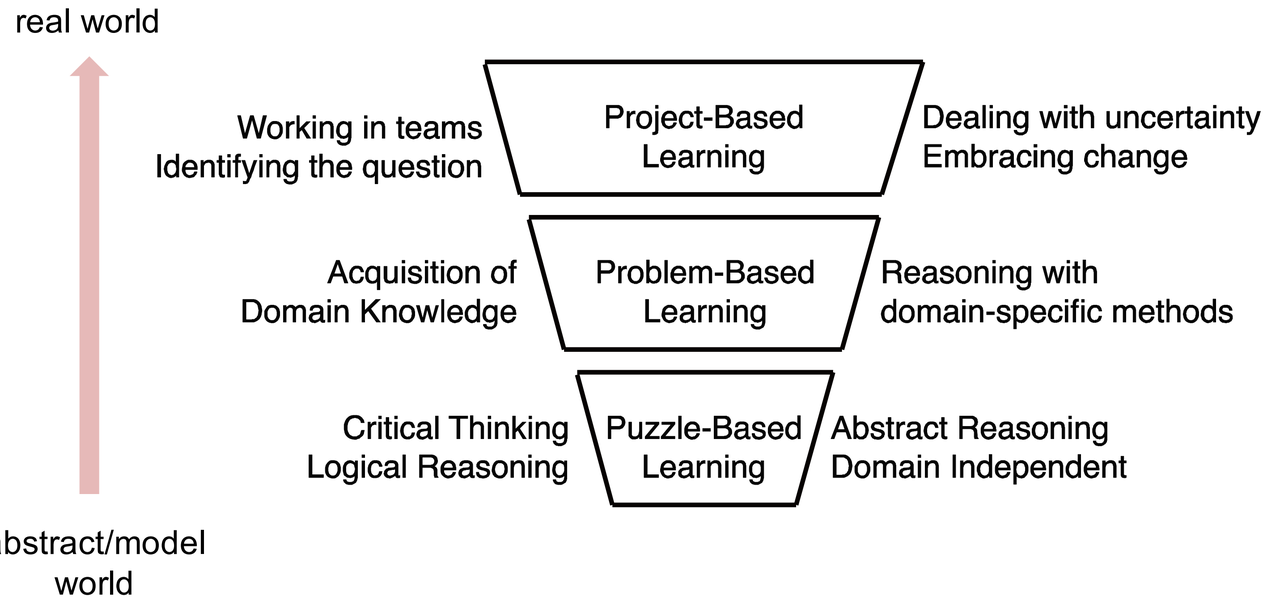
Why Puzzles?

- *Independence*: The puzzles are not specifically tied to a single problem-solving domain.
- *Generality*: Educational puzzles should explain some universal mathematical / problem-solving principles.
- *Simplicity*: Educational puzzles should be easy to state and easy to remember.
- *Eureka factor*: Educational puzzles should initially frustrate the problem-solver, but with the promise of resolution.
- *Entertainment factor*: Educational puzzles should be entertaining and engaging.

Topics Outline

Motivation / Introduction

1. **The problem:** What are you after?
2. **Intuition:** How good is it?
3. **Modeling:** Let's think about the problem a bit more
4. **Some mathematical principles**
5. **Constraints:** How old are my children?
5. **Optimization:** What is the best arrangement?
6. **Probability:** Coins, dice, boxes, and bears
7. **Statistically speaking**
8. **Let's simulate!**
9. **Pattern Recognition:** What is next?
10. **Strategy:** Shall we play?



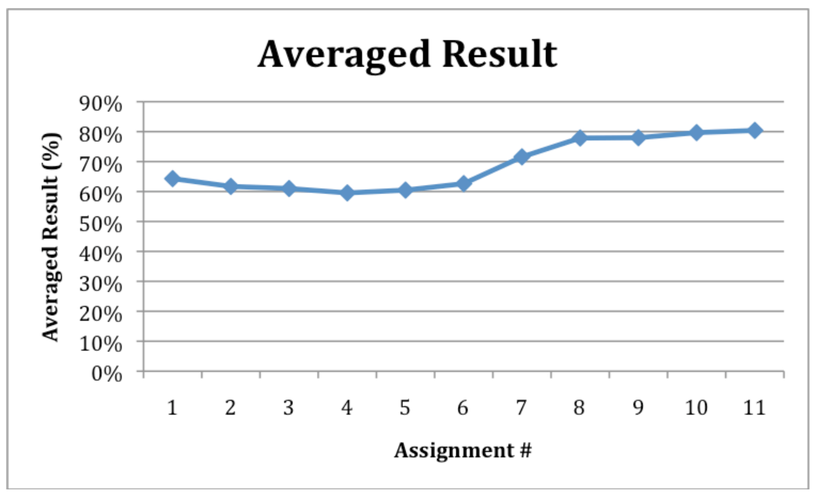
Heuristics and Strategies

- Understand the problem: given and needed
  - Backpackers, mushroom
- Simplify / iterate / increment
  - Pirates puzzle, Reverse game
- Build a model
  - Tax/discount, Fitch Cheney card trick
- Enumeration and Elimination
  - Blue-eyed boy
- Reason backwards
  - Real world problems, Coleridge apples
- Pattern Recognition
  - M-heart-8, Induction, Eleusis
- Draw a diagram
  - Mr. & Mrs. Smith

Lessons Learned

- Puzzles are constructed to force students to consider alternatives and develop an answer.
- Good puzzles have a misdirecting component to their nature. But we can't use outright deceit.
- You may need to *nudge* students onto the correct path, to minimize frustration
- Students need to be trained to overcome any natural resistance to puzzles:
- *Prime* them with worked examples, unmarked submissions and low-risk group solution activities.
- Reward innovation and exploration, and de-emphasize the importance of the correct answer.

Preliminary Evaluation



General trend in improvement in assignment performance. The value shown at a given assignment is the average of the assignment result and those on either side. Data from 103 freshman students intending to major in Computer Science at the University of Adelaide.

Sample Student Feedback

I enjoy coming to class because it is very hands on and allows me to use critical thinking.

This course seems to be expanding my mind by giving me new ways to interpret and solve problems that I would be completely lost on.

I have learned a lot about how to approach problems and the thought processes behind it. My ability to prove mathematical and logic proofs has improved.

I like that the course opens my eyes to independent critical thinking and learning new ways to approach problems.

You are taught a new way about attempting problems, helps in all courses, not just this one.

Stimulating abstract way to look at problems. Applicable to all my courses.

The lectures are entertaining and I'm continuously being challenged to prove my increasing problem solving skills.

It is fun and makes me think.

Interest Across the Education Spectrum

- Freshman seminar
- Graduate level course on Heuristic Problem Solving
- PBL components blended in other courses
- High school / middle school
- Continuing education (Osher @ CMU)
- Industry workshops
- Education workshops (SIGCSE, CSEET) for college and high school teachers

Carnegie Mellon University
Dietrich College
Information Systems

In collaboration with

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