

Problem-Solving Skill Development

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Challenge

- How to best prepare ISU students to tackle the ill-structured, multi-faceted problems they will face in their careers?
- Ill-structured problems
 - Multiple approaches to the task and criteria for choosing between proposals may not be completely specified.
 - Develop a plan to increase energy savings in your building.
- Well-structured problems
 - Apply a set algorithm to produce a unique answer
 - Calculate the power used in a given circuit

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Core Strategy

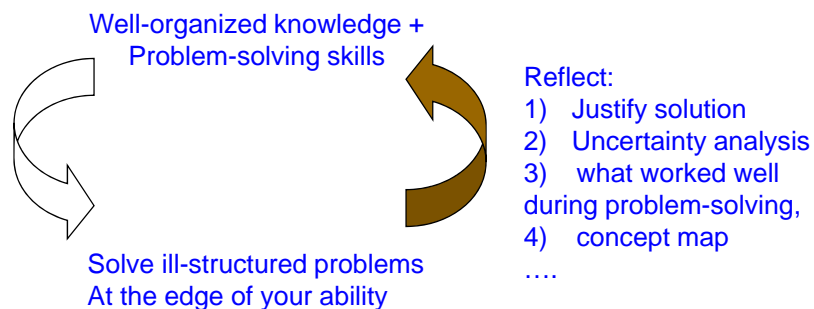
- Have teams of students work on ill-structured tasks from Day 1
 - Don't wait till senior-year, capstone courses, or internships
 - Takes time, practice to develop these skills
- Do this within each discipline, e.g. currently at ISU
 - Biology, horticulture, industrial engineering, physics, curriculum+instruction, Vet Med,...
- Steadily increase the complexity of the tasks

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Development of Expertise



Solving complex problems in teams
=> builds understanding, knowledge, increases process skills
=> which extends the “edge” of one’s competence

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Example of ill-structured problem

- **Physics**
 - “You are in charge of drinks at a picnic that will start at 3pm. Place ice inside a cooler at 6am, when temperature outside is 10°C. The day warms up steadily to reach 30°C by 3pm. Estimate how much ice you will need”
- **Horticulture (Ann Marie VanderZanden)**
 - “You have been hired by a local municipality to consult on a landscape situation tied to nitrogen and phosphorus run off into a local stream. The city has asked you to evaluate current management practices used by the landscape company maintaining the site, and recommend best-management practices (BMPs).”
- **Characteristics**
 - Difficult, so strong problem-solving skills vital
 - Info may not be fully specified
 - Involves more than one principle, concept...
 - Realistic, places student team at center of problem
 - Requires and builds organized understanding

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Problem-solving skills for ill-structured problems

- **Frame the problem**
 - What is involved, what is the goal, what criteria for success
- **Qualitative representation**
 - Analysis of components of problem, relationships, what is going on..
- **Planning**
 - Sketching steps of work before spending time on detail
- **Ongoing monitoring**
 - Periodic reviews for consistency, alignment with plan
- **Verification**
 - Does solution meet the goals, consistent with assumptions?
 - Uncertainty analysis, how robust is the solution to changes

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Group Exams: graded on process

- Held in regular recitation twice a semester
- Each student group gets a single multi-faceted problem
 - Several problems, each problem used once per room
- Problem-solving rubric (partial)

Criteria	Exemplary (4)	Competent (3)	Marginal (1)	Unacceptable (0)
Qualitative Representation	The problem is analyzed qualitatively, e.g. if a water-filled pan is on a stove, you predict the pan will warm up, which will warm the water. Then the water will start to boil and the pan might eventually become empty. The qualitative analysis identifies key moments or locations in the problem.	The problem is analyzed qualitatively but not all key moments or locations or other key elements are identified.	Qualitative analysis is inadequate and/or not focused on the problem	No qualitative analysis is done.

- Common grade each member of group (7.5% of final grade)

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To increase problem-solving at ISU

- Problem-solving outcomes group
- Two case delivery tools
 - Problem-solving Learning Portal (PSLP)
 - 1500 students per year, several departments
 - Including multi-national teams: Scotland, Taiwan, US, Mexico
 - Used for in-class complex problems, 50 min, to 3 week large-scale tasks, shared documents etc.
 - Diagnostic Pathfinder (Jared earlier this semester)
 - 300 students per year, currently vet med

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PSLP

Problem presented in main window
 Relevant, irrelevant info available on left
 Tasks to be completed in top tool-bar

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Dissemination

- **Open invitation to use PSLP/pathfinder in your classes**
 - Configurable to your categories of info, tasks to be completed, scale of problem to be solved
 - 1 hour to several weeks
 - Guest accounts + trial problems + workshops in Fall

- **CAC grant application**
 - Author module
 - Technical support for faculty adopters
 - Software development to make SCORM compliant
 - Useable in any delivery system, webCT, moodle
 - Open-source => share the maintenance load

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Benefits of Online Case Tools

- Track what students do as they work through cases
 - Scavenger approach, collect all possible info
 - Evolves => analyze first, then find relevant info
- Scaffold important skills, e.g. problem-framing
 - 1st case, provide example to students
 - 2nd case, provide guidelines
 - 3rd + future case, no scaffolds
- Real-time adaptive cases, feedback (future development)

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Problem-Solving Beliefs

- Students asked to reflect and describe their preferred method of solving physics problems
 - At start of semester and at end of semester
- ~ 200 responses coded (blind to pre/post)
 - List known quantities
 - Write goal
 - “match” between equation and known quantities “Roladex”
 - Find similar example in text
 - Diagram
 - Identify main concepts
 - Qualitative analysis
 - Identify sub-problems

Limiting strategies

Expansive strategies

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Listing Knowns

- The very first thing that I do is rewrite the information on the side so that it is easy to see and understand since it often gets confusing throughout a story problem.
- I write down the known facts and what I need to find. I assign variables to each fact--known or unknown alike. My biggest problem is finding information that isn't needed in the problem, and therefore, waste time.

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Equation Matching/Roladex

- I read through the problem noting the information given. Then I look for a formula that involves these variables.
- My general approach to a physics problem is to write out the given information then try to match what we are given to an equation on the sheet. This is fairly efficient for simple problems, but much more troublesome with complex problems.
- I usually figure out what variables I have and what I need to find. Then, I look for a formula that contains all of those variables and solve for what I need.
- Despite your warning against it, I still go equation-hunting. Equations are basically models of concepts, and so it's the equivalent of looking for the right concept. However, most of all, it works.

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Qualitative

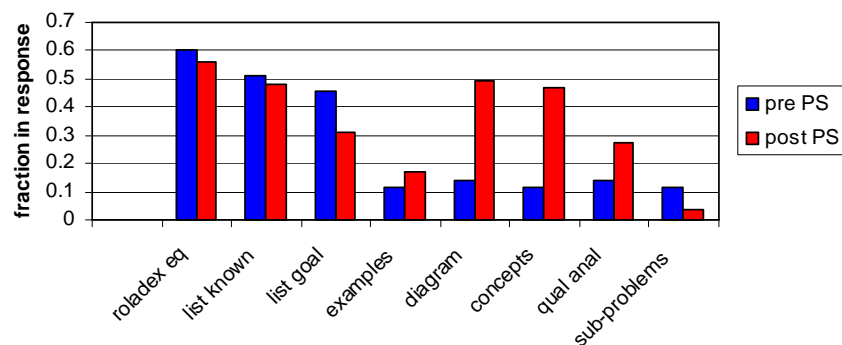
- Also, I think it's very important to talk myself through it qualitatively before touching any numbers or equations. After using equations and getting an answer, I ask myself if it makes sense.
- One of the first things I like to do is draw a picture that represents the problem. This helps me better understand what I am dealing with and what I will be looking for. If, after this, the problem is still confusing, go through my head at what would make logical sense in solving the problem. Sometimes for it to make sense, I have to imagine myself in the situation and think about what would occur in this situation. Once I think I understand what is happening, I look for the formula(s) that relate to the problem.

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Fraction of times method listed in a response



“Limited” strategies still mentioned post-instruction :
robust because these work for simple problems
More expansive strategies prevalent post-instruction

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Positive Comments

- This year has changed my approach to basic problems, first I instead of searching for an equation to solve the problem I now think about the problem in terms of its fundamental idea. I try to understand what the problem is all about and then map out what I need to find. Doing this I discover what the real problem is and then m able to apply the appropriate equations and common sense to solve the problem.

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Summary

- Ill-structured problem-solving skill should be a core outcome of a university education
- Takes practice
 - Early, pervasive exposure to these tasks
- Has the potential to increase
 - Structured understanding, links between isolated concepts
 - Skills such as problem-formulation, ongoing review...
- Open invitation to use PSLP in your course
 - Configurable to your needs
 - Start with trial problem.

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