

Laboratory of Computer Science Education

Problem solving

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David H. Jonassen. Toward a Design Theory of Problem Solving. Educational Technology Research and Development. 48(4):63-85 (2000)

- Problem solving is generally regarded as the most important cognitive activity in everyday and professional contexts.
- Unfortunately, students are rarely,if ever,required to solve meaningful problems as part of their curricula
- A major reason is that we do not understand the breadth of problem-solving activities well enough to support learners in them

Introduzione

Problem solving is any goal-directed activity sequence of cognitive operations

Or is it?

Manipulation of the problem space

Problem variations

Problem Variations	→ Representation	→ Individual Differences	= Problem Solving Skill
Ill-structuredness	Context	Domain knowledge	
Complexity	social	familiarity	
Abstractness/ situatedness (domain specificity)	historical cultural Cues/Clues Modality	perplexity experience Structural knowledge Procedural knowledge Systemic/conceptual knowledge Domain-specific reasoning Cognitive styles General problem-solving strategies Self-confidence Motivation/perseverance	

Structuredness

Well-defined problems

- Present all elements of the problem to the learners
- Require the application of a limited number of regular and well-structured rules and principles that are organized in predictive and prescriptive ways
- Have knowable, comprehensible solutions where the relationship between decision choices and all problem states is known

Ill-defined problems

- Possess problem elements that are unknown or not known with any degree of confidence
- Possess multiple solutions, solution paths, or no solutions at all
- Possess multiple criteria for evaluating solutions, so there is uncertainty about which concepts, rules, and principles are necessary for the solution
- Often require learners to make judgments and express personal opinions or beliefs about the problem, so ill-structured problems are uniquely human interpersonal activities

Structuredness

- I do not mean to imply that everyday practice does not include well-structured problems
- Ill-structured problems may become well-structured with practice
- However, everyday practice is more suffused with ill-structured problems than is educational practice
- Solving ill-structured problems in a simulation called on different skills than solving well-structured problems, including metacognition and argumentation

Complexity

Problem complexity is defined by the number of issues, functions, or variables involved in the problem; the degree of connectivity among those properties; the type of functional relationships among those properties; and the stability among the properties of the problem over time

- Complexity and structuredness overlap. Ill-structured problems tend to be more complex, especially those merging from everyday practice
- Most well-structured problems, such as textbook math and science problems, tend to engage a constrained set of variables that behave in predictable way

Domain specificity

Contemporary research and theory in problem solving claims that problem-solving skills are domain-and-context-specific

Problem representation

- An important function of designing for problem solving is deciding how to represent the problem to novice learners.
- Problems that are represented to learners in formal learning situations are usually simulations of every day and professional problems, so instructional designers decide which problem components to include and how to represent them to the learner.
- In order to do so, designers provide or withhold contextual cues, prompts, or other clues about information that need to be included in the learner's problem space

Tipi di problema

Table 2 □ Examples of problem types.

Logical Problems

Tower of Hanoi; Cannabals & Missionaries; how can I divide the water in the first jug and second jug using only three jugs; Rubic's Cube; draw four straight lines on 3×3 array of dots without removing pen from paper; divide triangular cake into four equal pieces

Algorithms

Factor quadratic equation; convert Farenheit to Celsius temperatures; bisect any given angle

Story Problems

How long for car A to overtake car B traveling at different speeds; apply Boyle's law to problem statement; calculate reagents needed to form a specific precipitate in a chemical reaction; most back-of-the-chapter textbook problems

Rule-Using Problem

Search an online catalog for best resources; expand recipes for 10 guests; how many flight hours are required to pay off a 777; prove angles of isosoles triangle are equal; calculating material needed for addition; change case to subjunctive

Decision-Making Problems

Should I move in order to take another job; which school should my daughter attend; which benefits package should I select; which strategy is appropriate for a chess board configuration; how am I going to pay this bill; what's the best way to get to the interstate during rush hour; how long should my story be

Tipi di problema

Troubleshooting Problems

Troubleshoot inoperative modem; why won't car start; determine chemicals present in qualitative analysis; determine why newspaper article is poorly written; identify communication breakdowns in a committee; determine why local economy is inflationary despite national trends; isolate cause of inadequate elasticity in polymer process; why are trusses showing premature stressing; why is milk production down on dairy farm

Diagnosis-Solution Problems

Virtually any kind of medical diagnosis and treatment; how should I study for the final exam; identifying and treating turfgrass problems on a golf course; develop individual plan of instruction for special education students

Strategic Performance

Flying an airplane; driving a car in different conditions; managing investment portfolio; how can I avoid interacting with person X; moving to next level in Pokemon game; teaching in live class; arguing points of law before court

Situated Case-Policy Problems

Harvard business cases; plan a menu for foreign dignitaries; render judgment in any tort case; develop policy for condominium association; evaluate performance of a stock portfolio; how should Microsoft be split up

Tipi di problema

Design Problems

Design instructional intervention given situation; write a short story; compose a fugue; design a bridge; make a paper airplane; design a dog house; design a vehicle that flies; developing curriculum for school; plan marketing campaign for new Internet company; develop investment strategy for money market fund

Dilemmas

Should abortions be banned; resolve Kosovo crisis; negotiate peace between Hutus and Tutsis in Rwanda; redistribute wealth through tax policies; develop bipartisan bill for U.S. Congress that will pass with $\frac{2}{3}$ majority