Anchors, Cases, Problems, and Scenarios as Contexts for Learning

Cindy E Hmelo and **N Hari Narayanan**
(Organizers)
EduTech Institute and College of Computing
Georgia Institute of Technology
Atlanta, GA 30332-0280
ceh,narayan@cc.gatech.edu

Abstract

The constructivist paradigm, which views learning as an active process in which students participate by engaging in activities that facilitate the construction of internal representations, is fast gaining currency as an innovative and effective way to overhaul classroom instruction. One way to promote constructivist learning is to firmly embed the acquisition of knowledge in realistic and stimulating contexts that challenge students to explore a variety of issues and employ a variety of their skills. This symposium will focus on four approaches (anchored instruction, case-based reasoning, goal-based scenarios, and problem-based learning) designed to contextualize learning in this fashion. They do so in different, yet related ways. Examples of these approaches, ways in which they are similar and different, and important concerns regarding their effects on student learning and performance will be some of the issues that panelists will address. The panelists in this symposium are: **Ray Bareiss**, Institute for the Learning Sciences, Northwestern University; **Cindy Hmelo, Janet Kolodner**, and **Hari Narayanan**, EduTech Institute, Georgia Institute of Technology; **Vimla Patel**, Center for Cognitive Science, McGill University; and **Susan Williams**, School of Education and Social Policy, Northwestern University.

Introduction

Research on human cognition during recent years has begun to reveal the different ways (and contexts) in which humans acquire new knowledge and skills, and transfer previously learned knowledge and skills to new situations. This, in turn, has had the effect of undermining the traditional view of classroom instruction as a vehicle for transmitting facts from the teacher to the students (Brown, Collins, & Duguid, 1989; CTGV, 1990, 1993). It is being replaced by the view of learning as an active process; a process in which students, instead of being passive recipients, participate in the learning process by engaging in activities that facilitate the construction of internal representations and integration of new knowledge with the old. This signifies a fundamental paradigm shift in education from the traditional transmission model to a more learner-centered approach (Brown et. al., 1993). This paradigm shift is of critical importance not just to the education community, but to the cognitive science community as well, primarily because it is research on cognition, and on technologies that support and amplify human cognitive processing, that will both drive this paradigm shift and provide the tools to implement and assess it in the nation's classrooms. Therefore, our goal in this symposium is to expose the broader cognitive science community to the significant issues and problems in this area.

Contextualizing Learning

One way to promote constructivist learning in classrooms is to firmly embed the acquisition of knowledge skills and strategies as well as facts in realistic and stimulating contexts that challenge students to explore a variety of issues and engage a variety of their skills. A number of terms -- such as anchored instruction, case-based learning, goal-based scenarios, learning-by-doing, learning-to-learn, problem-based learning, self learning and reflective learning -- have come into use, denoting different facets of this new view of learning. We will focus on four facets in this symposium: the use of anchors, cases, problems and scenarios to facilitate learning and transfer.

Anchors, cases and problems have all been proposed as contexts for learning (Barrows, 1985; CTGV, 1990; Kolodner, 1993; Williams, 1993). All three have the common characteristic of being rich situations that can afford generative problem-solving. Learning from cases may afford several advantages. First, the learners will encode knowledge in a context that is similar to the one in which it will ultimately be used, enhancing the likelihood of appropriate retrieval and transfer. Second, the learners may construct mental models of the underlying domain knowledge that include conditions under which the knowledge is applicable. Third, learning from cases may provide the learner with a library of specific instances from which to reason. Some forms of case-based learning explicitly promote self-directed learning skills as well. Several variations on the use of cases to enhance learning have been developed for diverse populations. Anchored instruction has been used widely in middle school mathematics instruction to promote the development of mathematical problem-solving skills and strategies. Problem-based learning (PBL) is being used in medical schools in the US and internationally to help students integrate biomedical science with clinical skills as well as facilitate the development of clinical reasoning strategies. Goal-based scenarios (GBS) provide frameworks for creating computer-based learning environments that promote learning while students pursue a set of specified goals (Schank, *et al.* 1993). However, some researchers are more cautious in embracing these new approaches, arguing that these in fact may lead to more fragmented knowledge (Patel, Groen, & Norman, 1993 but see Hmelo, 1995 for an alternative view). They have raised concerns about the deleterious effects that integrating fundamental and practical knowledge may have on the efficiency of reasoning, and about the adequacy and variety of reasoning strategies that students acquire (Patel, Arocha & Lecessi, 1995).

In light of the increasing interest in applying these methodologies to disciplines other than medicine and to broader student populations, the strengths and limitations of these approaches as well as how to effectively implement them, supported by technology, in classrooms have all become issues that merit further research and discussion. This symposium aims to stimulate both discussion and additional research on these aspects. In particular, the speakers will address questions such as the following:

- What makes for an effective anchor, case, problem, or scenario? In what ways are these similar or different?
- How do these promote learning, integration, retention and transfer? How can these be used in the classroom most effectively?
- Are there any disadvantages to using grounded instances in learning? If so, how can they be remedied?
- How can technology be used to enhance, scaffold, and contextualize learning? What form should computer-based learning environments to support these approaches take?

In the following sections we provide brief summaries of the four approaches that will be covered in the symposium: anchored instruction, case-based reasoning, problem-based learning and goal-based scenarios.

Anchored Instruction

In anchored instruction, learning is situated in rich, multimedia contexts that afford opportunities for problem finding, exploration, and discovery. In this approach, rather than beginning with a set of facts to be learned, students are introduced to a video-based problem, one that will provide challenges to them as they attempt to solve it. The multimedia presentation of the problem presents a situation as one would see it in the world, though it is orchestrated so that it has embedded in it all the data that students need to solve the problem. As in the real world, the presentation does not make clear which of the presented material is relevant to problem solving and which is incidental. Students must learn to differentiate between relevant and irrelevant data. The goal is to have students find and define problems, generate subgoals, and think about them over an extended period of time. The problems used in this approach use a narrative format to present information and create a meaningful context for problem solving (CTGV, 1990). The problems that are used are much more complex than typical math word problems on the premise that students cannot learn to deal with complexity unless they have had the chance to experience it.

Case-Based Reasoning

Case-based reasoning (CBR) addresses both problem solving and learning within a single framework a framework built around the notion of using past experiences to solve current problems (Kolodner, 1993). The central idea in case-based reasoning therefore is that cases, in the form of interpreted and encoded descriptions of previous problems and their solutions, are the primary generators of inferences, suggesting current solutions to problems, pointing the way out of quandaries, allowing potential failures and errors to be anticipated and avoided, and focusing attention. As cases are used in interpreting and solving new problems, new cases are generated and stored in the memory - this is the learning component of CBR. A case typically has the following characteristics:

- it describes a previously experienced episode of problem solving;
- it is an interpreted and encoded knowledge structure;
- it contains a rich variety of information, including
  - a description and important features of the problem that was solved,
  - the solution that was arrived at, and its important features,
  - a process description of the solution process, decisions that were made, and their justifications (rationale),
  - outcomes that resulted from carrying out the solution,
  - evaluation of the success/failure of the solution in terms of its outcomes, and
  - aspects found to have led to the success or failure based on this evaluation.

A case is indexed by the deep features of the problem, the solution, and its outcomes so that it can be retrieved based on similar problems or similar solution strategies that are being considered, or the expected outcomes. Cases can provide not only solutions that can potentially be adapted to fit a new problem, but also enable a learner to hypothesize the results of implementing a similar solution and provide warnings about potential pitfalls to avoid and successful avenues to pursue. In many domains, there is no well developed causal theory or the causal theory may be irregularly applicable across the variety of cases that a problem-solver may encounter. It is in these domains that cases can serve as valuable resources for both problem-solving and learning.

Problem-Based Learning

Problem-based learning (PBL) is an educational methodology in which students learn by solving problems and reflecting on their experiences. In problem-based learning, students face a problem situation with some high level goal that needs to be addressed, and learn by solving authentic real-world problems. Because the problems are complex, students work in groups, where they pool their expertise and experience and together grapple with the complexities of the issues that must be considered. Coaches guide student reflection on these experiences, facilitating the learning of the cognitive skills needed for problem solving, the full range of skills needed for collaboration and articulation, and the principles behind those skills. Because students direct their learning, skills needed for life-long learning are also acquired, for they must manage their learning goals and strategies as they cope with problems set for them. Experience in medical and business schools shows that problem-based curricula serve to enhance learning facts and concepts at a range of levels and to promote the learning of critical problem solving and collaboration skills needed for the workplace (Hmelo, 1994; Norman & Schmidt, 1992). The classical method of PBL was developed in medical schools (Barrows, 1985). Instead of the traditional lecture-based format, students learn biomedical science through solving problems. This form of PBL includes among its goals (1) developing scientific understanding through cases, (2) developing clinical reasoning strategies, and (3) developing self-directed learning skills. In this approach, small groups of five to seven students and a facilitator meet to discuss a patient case. The students receive an initial scenario and then must question the facilitator to get additional case information. At several points in the case, the students pause to reflect on the data they have collected so far, to generate questions about the data, and to hypothesize about underlying causal mechanisms for the patient's problems. The students must also identify issues that they do not understand and need to learn more about. After considering the case with their naive knowledge, the students independently research the learning issues they have identified. They then share what they learned, reconsider their hypotheses and/or generate new hypotheses in light of their new learning.

A significant transformation occurs as a result of the learning processes in PBL. The original problem which consists only of clinical data and some related background information becomes transformed into a case - comprising relevant symptoms from among those originally given to the students, the solution in terms of diagnostic hypotheses, an elaborated causal model that provides an account of how the hypothesized diseases give rise to the observed symptoms, conditions of applicability of this model, associational knowledge that links symptoms to hypotheses both positively and negatively, and connections to relevant and applicable scientific knowledge. When the problem corresponds to an actual clinical case, the students also learn the outcomes of the diagnoses - the therapy plan, whether their diagnoses were accurate or not, and why. These correspond to the components of a case as defined in CBR - the problem and its features, the solution and its features, rationale, outcomes, and evaluative information in terms of the success or failure of the solution and the reasons behind it. Thus, what develops in PBL is an interpreted and encoded representation of an episode of problem solving as a case in memory.

Goal-Based Scenarios

The motivating principle behind the development of goal-based scenarios as an educational framework as well as a framework for designing computer-based learning environments is that better learning can be achieved by presenting students with problems in their domains of interest along with well-defined goals and the means for achieving these goals. Thus, a GBS is a learning-by-doing task that requires a careful selection of materials to be taught, the goals students will pursue, the environment in which students will work, the subtasks that in the pursuit of their goals the students will engage in, and the resources that will be made available to the students. The scenarios are constructed and the goals are specified in such a way as to motivate students to accomplish the goals, and to enable them to acquire the necessary skills during this process of goal-accomplishment. Goal-based scenarios scaffold the acquisition of skills, by providing opportunities for the practice of skills in the pursuit of goals that also serve to illustrate the potential utility of these skills to students. The main components of a GBS, therefore, are a clear and concrete goal to be achieved, a set of target skills to be learned and practiced, and a task environment in which students will work. A GBS consists of a mission context and a mission structure. The mission context outlines the thematic aspects of a GBS by stating the goal students will pursue (called the mission) and the premises under which they will work (called the cover story). The mission structure describes the means by which students will pursue the mission, including the nature of the task involved (called the mission focus this may be, for instance, design, diagnosis, discovery, etc.) and the activities students can undertake in pursuit of the mission (called scenario operations). Guidelines on how to effectively design a GBS are given in (Schank, et al. 1993). Like the other approaches, GBS's are designed to allow students to learn within an realistic context.

Summary

This symposium is being organized around a set of four innovative approaches to learning, and the central issues and concerns that surround their deployment in classrooms. We will illustrate the different approaches with concrete examples, and then discuss their similarities and differences as well as the important issues and concerns regarding their use. The symposium will be structured as a series of short illustrations and presentations, followed by an open discussion involving the audience. These proceedings should be of considerable interest to the broad cognitive science community because the issues that we will address have been derived from fundamental research on human cognition and artificial intelligence. It will touch upon issues such as learning from instances, analogical transfer, case-based learning and reasoning, situated cognition, and problem solving; issues that have been at the center of cognitive science research. Furthermore, what we are concerned with is the application of cognitive science research on learning and instruction to the real world problem and national priority of improving education.

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