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Problem-Centered Instruction

We learn geology the morning after the earthquake.

RALPH WALDO EMERSON

USING PROBLEMS to initiate and anchor learning is an increasingly popular instructional strategy with roots going back to the early 20th Century. Problem-centered learning under various labels has been applied to diverse learning outcomes and settings, including near- and far-transfer tasks, educational and training goals, and classroom and multimedia delivery. The use of a work-realistic problem as a training centerpiece stimulates learner motivation by creating a "moment of need."

In this chapter, I review three instructional models that use problems to drive learning:

- Problem-Based Learning (PBL)
- The Four-Component ID Model
- A Cognitive Apprenticeship

Based on these models, I recommend some general guidelines to apply to any form of problem-centered learning.

The Revival of Problem-Centered Learning

Using problems to drive training is not new. In the early 1900s, John Dewey (1916) advocated instructional approaches that rooted learning in realistic problems or projects. In the years since the first edition of *Building Expertise,* I have seen increasing numbers of reports about lessons and courses that use problems to start and/or anchor learning events. As is common in our field, instructional approaches that rely heavily on problems have been called by various names. In this edition, I will review three instructional models that rely on problems or cases and that are supported by research evidence: (1) Problem-Based Learning (PBL) prevalent in medical education, (2) van Merrienboer's Four Component ID Model, and (3) A cognitive apprenticeship in the form of Sherlock, an intelligent automated tutor designed to build troubleshooting skills.

Problems in the form of work-related case studies or scenarios are in widespread use as the context for learning. Problems have been used to kick off near- and far-transfer learning in educational and training settings and in synchronous and asynchronous delivery modes. Problems are centerpieces in training designed for solo learning as well as in collaborative learning settings. Given the ubiquitous use of problems as instructional drivers in diverse settings and for diverse content, it is likely that you can adapt some aspects of these designs to your instructional goals. In spite of its popularity, problem-centered learning has its critics and has been the focus of a lively debate in the educational research community (See Kirschner, Sweller, & Clark (2006) and Volume 42, issue 3, of the *Educational Psychologist*).

What Is Problem-Centered Design?

I define *problem-centered design* as an instructional strategy in which tasks or problems relevant to the instructional objective are the context for learning. In problem-centered design, problem scenarios are:

1. Presented in the introductory phases of learning; they are the kickoff events for courses, modules, or lessons,
2. Based on authentic tasks specific to the domain of learning; they are job-specific and they incorporate content related to the job or educational objective.
3. The focal point for teaching knowledge and skills needed to resolve the problem.

Problem-centered designs range from relatively simple approaches in which problems or cases presented in print media serve as a source of learning issues to very complex guided discovery simulation-based multimedia lessons. The more complex designs derive problems and problem solutions from cognitive task analysis and often use simulation, incorporate coaching, and provide ways for learners to review "maps" of their problem-solving steps to compare with expert problem-solving maps.

The Benefits of Problem-Centered Design

Problem-centered designs offer a combination of psychological and motivational advantages, including support for learning transfer, learner popularity, engagement, teachable moments, integrated learning, and an opportunity to focus on problem-solving processes as well as outcomes.

Problems Promote Transfer

Do people learn better from courses that present knowledge and skills in an abstract manner or from courses that focus on specific examples and cases? For example, mathematics classes often teach computations, but not how or when the computations might be used in real-world contexts. This can lead to inert knowledge, as discussed in Chapter 11. Training classes may offer relevant skills and knowledge. However, only when new content is situated in job-realistic tasks are the resulting skills encoded in a real-world context. Proponents of using problems as vehicles to contextualize learning suggest that transfer of learning will be better from instruction that presents content in a relevant context. Problems can bridge the gap between general and specific knowledge since the general knowledge is learned in the context of specific applications.

Learners Like Problem-Based Learning

When learning from problems that are clearly applicable to real-world goals, the relevance of the training is highly salient. In contrast, lessons with content—even relevant content—presented outside of a real-world context often do not engage learners. Failing to see how the knowledge could be applied, learners don't see its value. Vernon and Blake (1993) report that medical students involved in problem-based learning classes like them better than traditional science education classes.

However, not all learners may embrace a problem-centered approach. Depending on their discipline and background experience, some may find it imposes too much cognitive load and therefore prefer a more traditional program that offers greater structure and direction.

Problems Promote Engagement

We know that learners must build their own knowledge and skill base in long-term memory. This is the meaning of constructivist learning. Therefore, active engagement with new content is an essential prerequisite to learning. By basing a lesson around a problem, the engagement process is initiated early in learning. If lessons are based on solving problems, engagement will permeate the entire experience. Starting with a problem makes learning a much more inductive experience, especially when the learner has multiple options to build the knowledge base needed to solve the problem. Alternatively, learning new knowledge and skills while solving a problem may impose too much cognitive load—especially for learners who are novices (Kirschner, Sweller, & Clark. 2006).

Problems Lead to "Teachable Moments"

In the context of trying to solve a problem, the learner realizes she needs related knowledge and skills. Challenged with solving a relevant problem, learners experience a readiness for learning—an openness of the mind to embrace new content and to immediately apply it. Teachable moments point to "just-in-time" instruction—providing relevant information and skills when the mind is most ready to receive them. Many problem-centered lessons begin with problems, followed by instructional resources ranging from traditional lectures to resources for self-study that provide relevant content needed to solve the problem.

Problems Provide Vehicles for Integrated Learning

In the real world, experts draw on integrated multi-component knowledge bases to solve problems. For example, in electronic troubleshooting, an extensive cognitive analysis showed that experts used three knowledge components: (1) a model of how the system works—its components, subcomponents, and the circuitry related to each; (2) procedural knowledge of how to conduct and interpret diagnostic tests; and (3) strategic knowledge of where to test first, based on a blend of pragmatic and theoretical considerations. A typical troubleshooting class might teach test procedures and/or it might teach system knowledge. But without a troubleshooting scenario as a context for learning, the content may fail to integrate around real-world work requirements.

Problems Focus on Thinking and Learning Processes

In jobs that involve problem solving—which include most knowledge worker jobs—learning the mental approaches to solving problems in a given domain is just as important as learning the content. For example, in the electronic troubleshooting training mentioned above, experts use heuristics to guide their action paths. The rationale of many experts solving diverse problems on specific equipment was used as a source to derive general troubleshooting guidelines. These guidelines were then modeled and practiced in the training program. More details are presented in the description of the troubleshooting training later in this chapter.

Three Problem-Centered Design Models

The three instructional models I describe in this section use problems as kickoff and anchoring devices. I will start with models that are less complex and move to more complex implementations. Table 13.1 summarizes their major features. Following a summary of these models, I will discuss the commonalities among them as the basis for a problem-centered approach to instruction.

Model 1: Problem-Based Learning (PBL)

Hmelo-Silver (2004) defines *problem-based learning* (PBL) as "focused experiential learning organized around the investigation, explanation, and resolution of meaningful problems" (p. 236). PBL is considered to be the most significant innovation in medical education in the past fifty years (Norman, 2004). PBL started at McMaster University in Canada in the 1970s and has since been adopted on a world-wide scale. PBL reflects a dramatic shift from "traditional" academic models that relied primarily on

Table 13.1. A Summary of Problem-Centered Design Models

Model	*Description*	*Example*	*Comments*
Problem-Based Learning	Small learning teams initiate a lesson by discussing a job-realistic case scenario. The team defines learning issues and reviews resources to resolve.	See Exhibits 13.1 and 13.2.	Widely used in medical education. The most extensively evaluated of all problem-centered instructional models.
Four Component ID Model by van Merrienboer	Individuals learn while resolving far-transfer tasks. The four components of the model are far-transfer tasks, supportive information, near-transfer tasks, and drill-and-practice of procedures as needed	Law students learn how to prepare a legal plea.	Researchers of this model have focused on techniques to manage cognitive load while learners solve problems.
Cognitive Apprenticeship	Learning occurs while performing tasks under the guidance of a mentor (live or automated).	Sherlock multimedia program trained technicians to troubleshoot electronic equipment	Twenty-five hours on Sherlock resulted in competency of ten-year technician.

large group science-based lectures to small tutorial groups that structure their learning around clinical cases. Although PBL started in medical education, some universities have adopted PBL into diverse curriculum areas, including health sciences, law, economics, and psychology (Schmidt & Moust, 2000). In fact, interest in PBL has grown sufficiently to warrant its own journal that debuted in 2006: *The Interdisciplinary Journal of Problem-Based Learning.*

Problem-based learning is characterized by the following four features:

1. A student-centered approach that relies on the learner to identify and review knowledge needed to resolve a case
2. Use of an authentic problem introduced to the tutorial group prior to any preparation or study
3. Synchronous small group collaborative work supported by a faculty facilitator, combined with self-directed study to investigate learning issues that arise from problem discussion
4. Use of the problem and tutorial discussion of the problem as vehicles to identify the required knowledge (facts and concepts) as well as problem-solving skills to resolve it

A typical PBL session begins with a team review of a case problem such as the story of the miserable stomach shown in Exhibit 13.1. The learning team discusses the case to clarify its meaning and to develop hypotheses to explain it. Known facts are identified as well as knowledge gaps. These are recorded on a white board such as the one shown in Exhibit 13.2 based on discussion of a medical case. Team members then work individually to research the learning issues. At a follow-on session, the team reconvenes to discuss what they learned, refine their initial hypotheses, and identify action steps or problem solutions.

EXHIBIT 13.1. A PROBLEM FROM A MEDICAL LESSON

The Miserable Life of a Stomach

The protagonist of our story is the stomach of a truck driver who used to work shifts and who smokes a lot. The stomach developed a gastric ulcer and so the smoking stopped. Stomach tablets are now a regular part of the intake.

While on the highway in southern Germany, our stomach had to digest a heavy German lunch. Half an hour later, a severe abdominal pain developed. The stomach had to expel the meal. Two tablets of acetyl salicylic acid were inserted to relieve the pain (the truck driver had forgotten his stomach tablets!). A second extrusion some hours later contained a bit of blood. In a hospital in Munich an endoscope was inserted. The stomach needed to be operated on in the near future.

Explain.

From Schmidt and Moust, 2000

EXHIBIT 13.2. AN EXAMPLE OF A PBL WHITEBOARD

Case Data	Hypotheses	Learning Issues	Action Plan
Fever	Infection	Infectious Strains	Order Lab tests - Blood - Culture - Xray
Sore Throat		Disease Cycle	
Cough-Blood		Treatment Alternatives	Research Drugs

What Have Medical Educators Learned About PBL?

Medical education is critical and expensive. Therefore, a number of research studies have compared learning and motivation among individuals in a "traditional" curriculum with that of learners in a PBL format. The first wave of research asked the question: *Does PBL work?* Enough research has been conducted to support a meta-analysis of results (Dochy, Segers, Van den Bossche, & Gijbels, 2003) as well as several recent reviews, for example, Hmelo-Silver (2004) and Mamede, Schmidt, and Norman (2006). Here are the lessons learned:

1. PBL does not yield better learning of science knowledge and facts. In fact, PBL may be somewhat disadvantageous compared to the traditional curriculum. Dochy and his colleagues (2003) based a meta-analysis on forty-three comparisons that were empirical, carried out in real-life classrooms, and compared PBL with traditional learning of facts and concepts. They found a negative effect of PBL on the student knowledge base, with an average effect size of –0.223. The authors conclude that the negative effect of PBL on knowledge is "small and not practically significant."

2. PBL leads to better clinical problem-solving skills. The Dochy meta-analysis also evaluated PBL versus traditional curricula on application tests–tests that assess how learners can apply their knowledge to medical cases. They found a moderate practical positive effect of PBL on application skills with an effect size of +0.460. Hmelo-Silver (2004) concludes that PBL students perform slightly better than traditional medical students on tasks related to clinical problem solving.

3. Medical students like PBL better than traditional curriculum. The popularity of PBL has been a consistent finding from the earliest research on PBL in medical education. PBL students are more satisfied and confident in their learning than students in traditional programs. Dolmans and Schmidt (2006)