CHAPTER OUTLINE

15

e-Learning to Build Thinking Skills

WHAT'S NEW IN THIS CHAPTER?

WHEN YOU HELP LEARNERS BUILD thinking skills, you enable the workforce to quickly adapt to changing conditions. For example, in the military, Chatham (2009) observes: "Today's missions now require that we also train each soldier to be a little bit of a linguist, anthropologist, city manager, arbitrator, negotiator, engineer, contract specialist, ambassador, and a consummate bureaucrat within the Army system. As if that weren't enough, each soldier must be ready instantly to shift into a shooting mode and then an hour later calmly negotiate with the brother-in-law of the man he shot" (p. 29). How many job roles in your organization rely on flexible problem-solving skills? From managerial skills to consultative sales and customer service, nearly all organizations rely on multiple competencies that require thinking skills to achieve bottom-line performance goals.

In the second edition of *e-Learning and the Science of Instruction,* we provided evidence and guidelines for using e-learning to build job-specific thinking or problem-solving skills. We emphasized some unique features of e-learning that can make mental problem-solving skills explicit. We recommended against using a broad approach to thinking skills training in favor of a job- or domain-specific focus. These recommendations are still valid. To update this chapter, we expand our discussion of domain-specific whole-task multimedia learning environments as well as offer more details on cognitive task analysis to identify job-specific thinking processes.

DESIGN DILEMMA: YOU DECIDE

"I wish our employees were better thinkers! Too much of our training involves soporific decks of PowerPoint or classes that teach step-by-step tasks in a rote manner. We need a workforce that can adapt quickly to new technology, new products, changing economic conditions—well, to a changing world in general. Our success relies on flexibility. I want everyone to take thinking skills training!"

That was the message from senior management. Your team leader led the kick-off meeting: "Management wants training on problem-solving skills and they want it for everyone, including operations, marketing, sales, engineers, and supervisors. We've got two weeks to report back with either a design for the training or with recommendations for off-the-shelf courseware that would do the job."

Back at your desk, you do a Google search on thinking skills training. You are amazed to get over nine million hits! As you access websites like the one in Figure 15.1, you are surprised to see the number and diversity of different classes and books that promise to make people more creative and better problem solvers. After reviewing some of the options, you end up with more questions than you had originally. Can thinking skills be trained? Are there some general thinking skills that can apply to most of the jobs in your organization? Shouldn't thinking skills be taught in a face-to-face learning environment rather than e-learning?

Based on your own experience or intuition, which of the following options would you select:

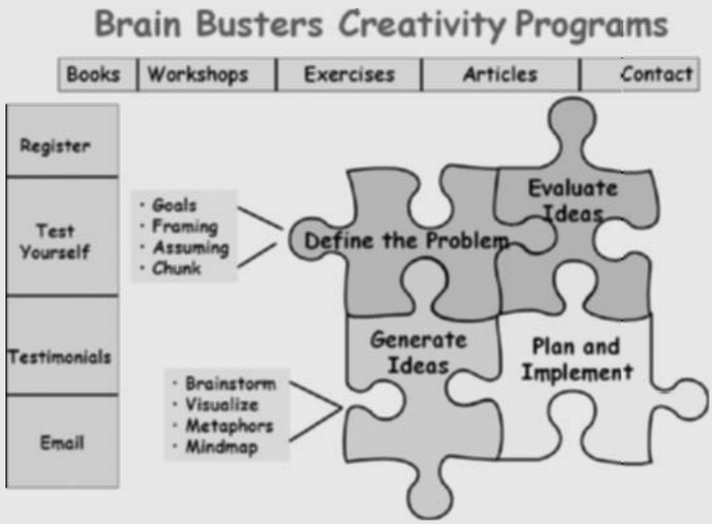
A. Money can be saved by purchasing an off-the-shelf course that includes techniques like the ones listed in Figure 15.1.

B. Thinking skills training would be most effective in a face-to-face environment.

C. Thinking skill training should be job specific; no one general thinking course will translate into improved work performance.

D. There is no way to improve thinking through training; it's like intelligence—you either have it or you don't.

Figure 15.1. A Website Promoting Thinking Skills Resources.



Three Types of Thinking Skills

Thinking skills training programs are popular. Over 25 percent of organizations with more than one hundred employees provide some form of thinking or creativity skills training (Scott, Leritz, & Mumford, 2004). But what do we mean by thinking skills? In Table 15.1. we summarize three types of thinking skills: creative thinking, critical thinking, and metacognition. By creative thinking we refer to the skill of generating novel and useful ideas. Most design work, such as creation of a new website, training course, or marketing plan, relies on creative thinking. Critical thinking involves evaluation of products or ideas. For example, when doing Internet research, a critical thinker considers the credibility of the resources. She might review the expertise of the author, consider the credibility of the publication, and determine when the information was posted.

Metacognition is the super-ordinate thinking skill of planning, monitoring, and evaluating new products or ideas. In Chapter 14, we defined metacognition as the skill that sets goals, plans an approach, monitors progress, and makes adjustments as needed. People with good metacognitive skills focus not only on the outcome of the task, but on the rationale or process behind the decisions made to achieve that outcome. When working in a team, the person with high metacognitive skills will be the one to say: "Wait—let's stop and see whether we're making progress. Will our individual efforts come together?" When working on a problem alone, he might say: "I'm hitting some dead ends here. Where can I get some help?" When a mission or project is completed, she will organize a debriefing session in which lessons learned are articulated and documented. In other

Table 15.1. Three Types of Thinking Skills.

Type	*Description*	*Examples*
Creative Thinking	Generating novel and useful ideas	Design an e-learning course Create a marketing campaign Draft an architectural plan
Critical Thinking	Evaluation of products and ideas	Evaluate validity of Internet resource Consider pros and cons of a new marketing campaign
Metacognition	Your mind's operating system responsible for setting goals, monitoring progress, adjusting approaches	Assessment of what you do and do not know Identify skills you are not learning Monitor progress in a team setting

words, the metacognitive worker or team is mindful of his or her specific thinking processes.

Can thinking skills be trained? Which of the three thinking skills listed in Table 15.1 would be most important to achieve specific outcomes? What training methods are best? In what ways can technology support the acquisition of thinking skills? Can practice with techniques like the ones shown in Figure 15.1 build better thinkers? How can we best identify the thinking skills of our expert performers? These are some of the issues we consider in this chapter.

Can Thinking Skills Be Trained?

Before considering specific guidelines for building thinking skills, it makes sense to first ask whether there is any evidence that they can be enhanced through training at all and, if so, what types of training work best. Because a number of wide-scale thinking skill programs have been evaluated, we have data on the outcomes from thinking skills training. Reviews of both educational and organizational thinking skills programs by Mayer (2008), Ritchhart and Perkins (2005), and Scott, Leritz, and Mumford (2004) conclude that thinking skills programs do have positive effects with some degree of transfer to tasks similar to those included in the programs. However, "this is not to say that such results demonstrate overwhelming success. Impacts on learners' thinking are typically moderate rather than huge" (Ritchhart & Perkins, p. 780).

A comparison of more successful with less successful thinking skills programs helps us identify the features of effective programs. Mayer (2008) notes that successful programs (1) focus on a few well-defined skills, (2) contextualize those skills within authentic tasks, and (3) incorporate social learning strategies, including instructor modeling and student collaboration. We conclude that thinking skills programs can be effective but, as with other skill training, job-specific thinking skills must be defined and trained using many of the proven techniques we have reviewed throughout this book. You will obtain greatest transfer when you integrate job-specific thinking skills into training on job tasks rather than create or implement stand-alone generic thinking skills courses.

To help you design or select programs that are likely to give you a return on investment, we offer the following guidelines:

Principle 1: Focus on job-specific cognitive and metacognitive skills

Principle 2: Consider a whole-task course design

Principle 3: Make thinking processes explicit

Principle 4: Define job-specific thinking processes

Thinking Skills Principle 1: Focus on Job-Specific Cognitive and Metacognitive Skills

It would be wonderful if training on general problem-solving techniques, such as those illustrated in Figure 15.1, could boost thinking skills across a spectrum of jobs. If this were the case, the thinking skills that underlie problem solving would be *general*, with applicability to many different career fields. A general thinking skills training approach like the one in Figure 15.1 would be quite efficient, since one training course on a set of generic problems would suffice for all employees in all work roles.

What's wrong with this approach? We know that successful training must transfer back to the job after the learning event, and transfer has proven to be a thorny problem. Our goal in improving worker thinking skills is to enable them to solve non-routine problems, that is, novel problems for which they do not have a standardized response. We know that work-related problems are encountered in a specific job context, such as sales, military threat assessment, patient care, or automotive troubleshooting. It is unlikely that the general skills derived from broad thinking skills training will transfer effectively to these diverse settings.

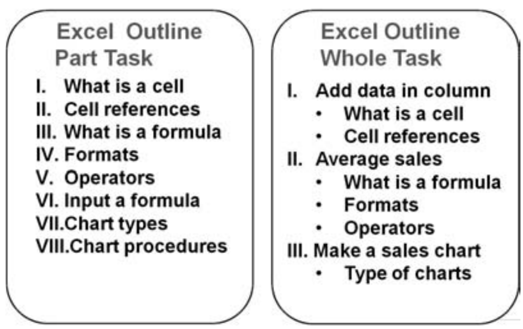
Throughout this book we have focused on instructional modes and methods primarily designed to help learners build knowledge and skills that underlie performance of specific tasks. In this chapter, we look at complementary thinking skills, including job-specific creative thinking skills, critical thinking skills, and metacognitive skills. Rather than teach a one-size fits-all list of generic thinking skills in dedicated training events, we recommend that you identify job role-specific skills and integrate these skills into the technical training designed for those work roles.

Thinking Skills Principle 2: Consider a Whole-Task Course Design

In Chapter 1 we defined three types of instruction for e-learning courses: teaching by show-and-tell (receptive), teaching by show-and-do (directive), and teaching by problem solving (guided discovery). Directive training is a type of *part-task instruction* in which content is broken into small segments, prerequisite knowledge is usually taught first, and frequent practice with feedback helps learners build skills gradually.

In contrast, *whole-task instruction* begins the lesson with an authentic work assignment and integrates the needed knowledge and skills in the context of working on that assignment. Whole-task instruction is one form of guided discovery also called *scenario-based learning*, *case-base learning*, or *immersive learning.* Because whole-task instruction teaches skills in context of a realistic work task, it offers opportunities to teach thinking skills along with cognitive skills. Compare the lesson outlines for an Excel course shown in Figure 15.2. Which outline reflects a part-task design and which a whole-task approach?

Figure 15.2. A Part- and Whole-Task Lesson Design for Excel.



If you identified the outline on the left as a part-task design, you are correct! Let's get a tangible feeling for whole-task lesson designs by looking at three examples and using them to summarize the key features of whole-task instruction.

Example 1: Problem-Based Learning

About forty years ago, McMaster's University in Canada initiated a major change in their medical school curriculum which subsequently has been widely adopted as an alternative to a traditional science-focused curriculum. In problem-based learning (PBL), the science lectures that predominated the first two years of medical school are replaced by small team reviews of medical cases such as the example we show in Figure 15.3. Typically, a team of five to seven students facilitated by a faculty member reviews a case together and reaches a common understanding of the case followed by individualized self-study to learn more about the issues in the case. After a period of time, the team reconvenes to debrief lessons learned. Most PBL programs follow a structured process such as:

1. Clarify unknown terms and concepts.
2. Define the problem in the case.
3. Brainstorm to analyze the problem by identifying plausible explanations (creative thinking).
4. Critique explanations produced and draft a coherent description of the problem (critical thinking).
5. Define the learning issues (metacognitive thinking).
6. Engage in self-directed study to fill the gaps specified by the learning issues (metacognitive thinking).
7. Reconvene to debrief the case and share lessons learned.

Many evaluation efforts have been directed at PBL, often comparing learning and motivation between PBL and the traditional curriculum. We will review this research later in this chapter.

Figure 15.3. A Case Problem Used in PBL.

From Schmidt and Moust, 2000.

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 not 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 acetylsaliclic acid were inserted to relieve the pain.

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 upon in the near future. Explain.

Example 2: Automotive Troubleshooting

In Figure 15.4 you see the interface for a multimedia whole-task practice environment for automotive troubleshooting. The task assignment begins

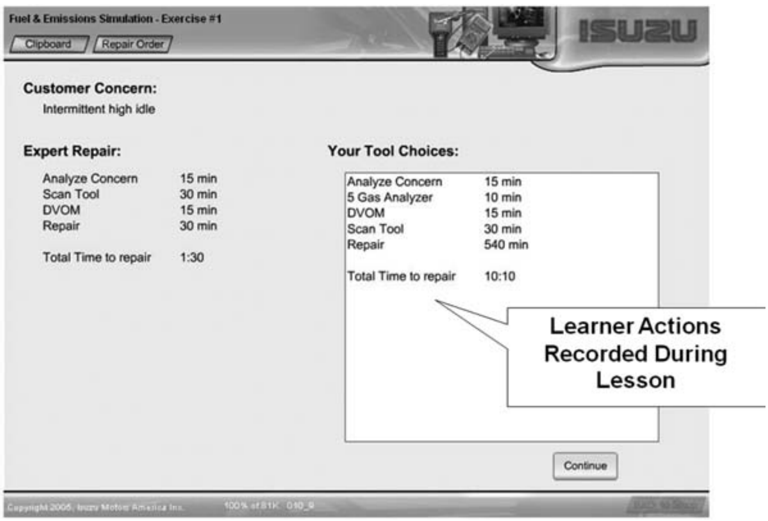
Figure 15.4. A Multimedia Interface for Automotive Troubleshooting.

With permission from Raytheon Professional Services.

with a work order that states the symptoms of a malfunction, such as high idle. The learners can conduct tests using the virtual shop equipment to identify the source of the failure. Once they believe they have identified the fault, they can select their answer from a list of about fourteen different failures. When they have completed the case and resolved the failure, the learners compare their diagnostic decisions and repair actions with those of an expert, as shown in 15.5.

Figure 15.5. A Comparison of Learner with Expert Problem-Solving Actions During Automotive Troubleshooting.

With permission from Raytheon Professional Services.



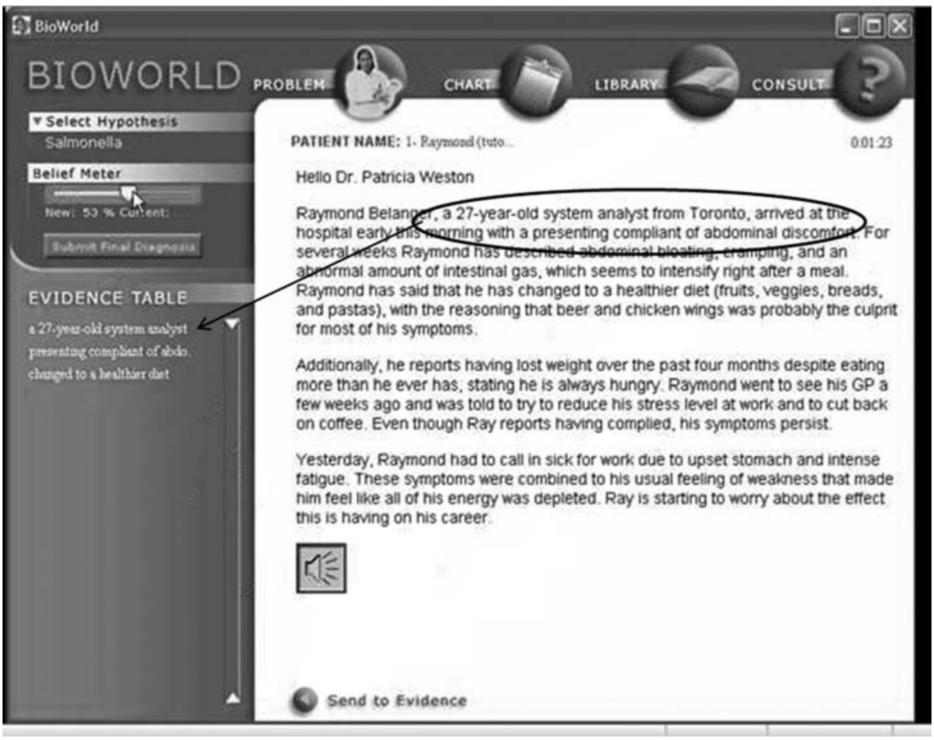
Example 3: BioWorld

BioWorld is a multimedia environment designed to teach scientific reasoning processes, including evidence gathering and analysis. Originally designed for high school students, BioWorld is currently being adapted for medical students (Lajoie, 2009). As shown in Figure 15.6, BioWorld displays a text description of a patient case. The learner begins by selecting relevant phrases mentioned in the case description and dragging them into the evidence table located in the left frame. For example, in this case involving a complaint of abdominal discomfort, the learner has selected patient age, complaint, and recent dietary changes. After identifying relevant evidence, learners select an initial hypothesis from the "Select Hypothesis" pull-down menu located in the upper left-hand corner. In this example, the learner selected Salmonella and can then order diagnostic tests from a pull-down menu to support the hypothesis. Learners can access resources from the online library at any time, including information on biological terms, diagnostic tests, and symptoms. At the conclusion of a case, learners prioritize the evidence supporting their diagnoses and can compare their priorities to those of an expert. As we write this chapter, an animated demonstration of BioWorld is located at www.education.mcgill.ca/cognitionlab/bioworld/en/BWTutorialsmall/BWTutorialsmall.html.

BioWorld includes many elements of an effective thinking skills program. First, it is domain specific—focusing on teaching of medical case reasoning. Second, it is case-based. The learning is contextualized within the process

Figure 15.6. The Learner Moves Relevant Data into the Evidence Table in BioWorld.

www.education.mcgill.ca/cognitionlab/bioworld/en/BWTutorialsmall/BWTutorialsmall.html. Accessed September 2010.



of gathering evidence about a patient and forming diagnostic hypotheses. Third, it makes scientific reasoning explicit by requiring learners to select a hypothesis and build and prioritize evidence to support it. Fourth, it offers instructional support in the form of library resources. Fifth, BioWorld provides feedback on the accuracy of the hypotheses as well as the prioritization of evidence.

Features of Whole-Task Instruction

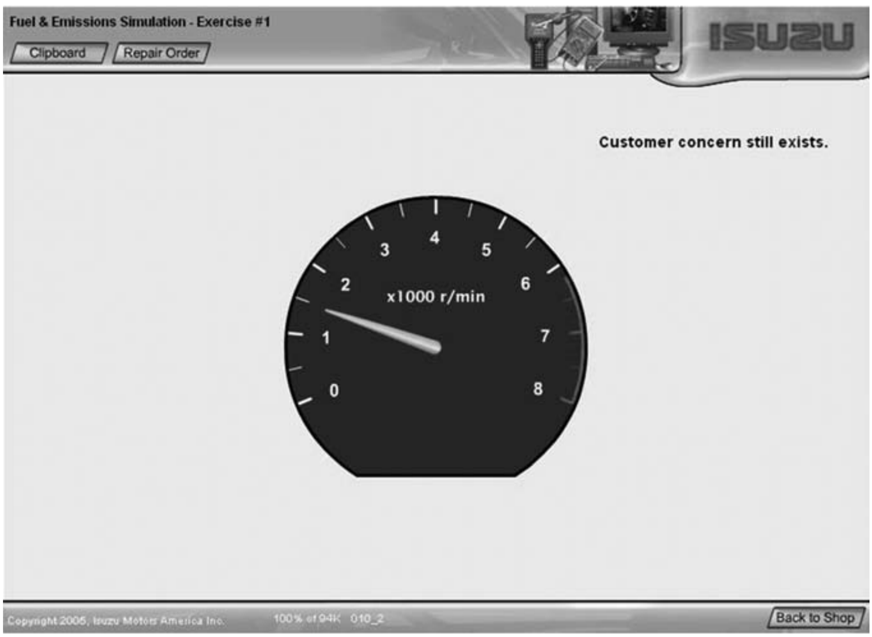
Now that we have taken a quick tour of three whole-task learning environments, let's summarize the main features that distinguish a whole-task from a part-task design:

1. *Problem-Centered.* Learning starts with a job-realistic scenario or problem, as shown in Figures 15.3 and 15.6. Case studies are not new to training. However, in part-task designs, the case study is sequenced at the end of a lesson or series of lessons. In contrast, in whole-task learning, the lesson is initiated by a case scenario that serves as the context for learning.
2. *Guided Learning.* Learners are supported during the problem-solving episode to avoid mental overload. In part-task instruction, component lesson topics are sequenced one at a time in a building block fashion to avoid mental overload. To minimize overload in whole-task learning, the design must manage the complexity of the scenarios as well as the amount of help available. Early lessons begin with a simple scenario the solution for which might be demonstrated by an expert. Later lessons include complex scenarios with more variables and require the learner to do most of the work.
3. *Inductive Learning.* Learners have freedom to try different actions and reflect on outcomes. Part-task lessons take a directive approach in which learners view examples and complete short practice exercises similar to those we showed in Chapters 11 and 12. The practice exercises are followed by immediate explanatory feedback. In contrast, whole-task designs use a more inductive approach in which the learners can try a number of actions and may not receive feedback until

they submit a case resolution. The feedback may be intrinsic. By that we mean that, after taking an action, the learners may see the consequence of their action and infer the accuracy of their action from that consequence. For example, in the automotive troubleshooting lesson, an incorrect response results in the feedback you see in Figure 15.7. At the end of the case, a summary of their problem-solving actions to promote reflection is displayed next to the actions of an expert, as shown in Figure 15.5.

Figure 15.7. Intrinsic Feedback Given to an Incorrect Response During Automotive Troubleshooting.

With permission from Raytheon Professional Services.



Evidence for Whole-Task Instruction

Although there is a lot of enthusiasm for whole-task learning, evidence of its effectiveness has been mixed. In this section, we review a sampling of research studies comparing learning from various forms of whole-task instruction with an alternative approach.

Evidence from Problem-Based Learning

Because problem-based learning has become a widely adopted alternative in medical education, many studies have compared outcomes among medical students who studied in a PBL curriculum with medical students who studied in a traditional lecture science-based curriculum. Conclusions have varied. For example, Schmidt, Van der Molen, te Winkel, and Wijnen (2009) reported a meta-analysis of 270 research studies comparing outcomes between PBL and traditional medical students in a single medical school. They conclude that medical knowledge and diagnostic reasoning were generally equivalent between the two groups. In contrast, interpersonal skills, practical medical skills, and student satisfaction ratings favored the problem-based learning approach. Koh, Khoo, Wong, and Koh (2008) reviewed thirteen studies involving post-graduate assessment of medical competencies comparing physicians who studied via PBL with those who studied under a traditional program. Assessment scores showed that the social dimension, including teamwork skills, appreciation of social and emotional aspects of health care, and communication skills were higher among PBL graduates. There were no differences for other competencies.

In contrast, Albanese (2010) concludes: "Research on the effectiveness of PBL has been somewhat disappointing to those who expected PBL to be a radical improvement in medical education. Several reviews of PBL over the past twenty years have not shown the gains in performance that many had hoped for" (p. 42).

Although the effects of PBL on learning and medical competencies have been mixed, most reviews agree that, overall, students rate PBL more favorably than the traditional curriculum. Perhaps learning in the context of real-world patient cases makes the relevance of the lesson more salient and hence increases motivation. However, keep in mind that medical students are a unique population whose learning preferences may not match your audience.

Evidence from Sherlock

Sherlock is a computer-coached whole-task practice environment focused on troubleshooting realistic failures in the F-14 electronic test station. Sherlock was designed to provide automated apprenticeship-like training for airpersons who completed their technical school training. Similar to the automotive troubleshooting example we described previously in this chapter, the Sherlock environment emulated the real shop and provided a practice environment in the context of realistic troubleshooting assignments. An Air Force evaluation of Sherlock found that trainees who were on the job for six months and spent twenty to twenty-five hours working with Sherlock were as proficient in troubleshooting the test station as technicians who had been on the job four years (Lajoie, 2009).

This acceleration of expertise stems no doubt from the compressed experience that Sherlock offered. In the real-world troubleshooting environment, failures were infrequent and occurred in no specific order of complexity. In other words, the real world did not provide the optimal frequency and sequence of problems for learning. An important lesson learned from Sherlock is the opportunity to accelerate expertise through experience with digital cases that in the real world could take months or years to accumulate.

Evidence from Excel Training

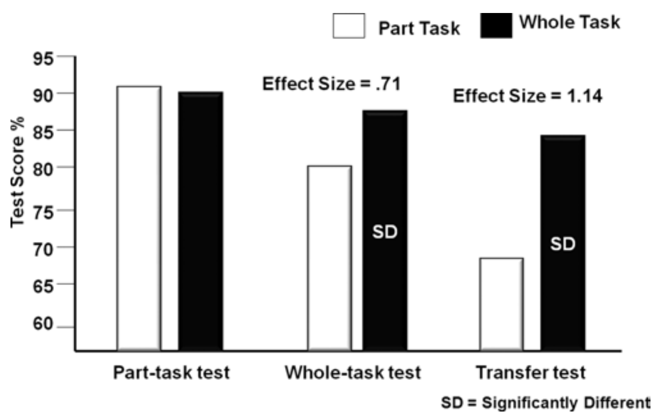
Lim, Reiser, and Olina (2009) compared several learning measures from part-task and whole-task learning environments teaching how to use Excel to prepare a grade book. Student teachers were randomly assigned to a face-to-face class that used either a part-task or whole-task design. In the part-task version, twenty-two component Excel skills, such as entering data, merging cells, or copying a formula, were described and demonstrated followed by immediate student practice of each component skill at the learner's workstation. At the end of the second lesson in the part-task program, learners were assigned to complete a grade book.

In contrast, the whole-task lesson started with an instructor demonstration of how to use Excel to create a simple grade book. Immediately after the demonstration, learners completed the same grade book just demonstrated. Then they created a second grade book using different data. In the second class session, the same pattern was followed constructing a more complex grade book that involved weighted averages. In summary, learners in the part-task version practiced many small component Excel skills and had one opportunity to practice setting up a grade book. In contrast, the whole-task group had the opportunity to set up four grade books: two simple grade books in Session 1 and two complex grade books in Session 2.

Three different tests taken by learners in both groups evaluated learning. A part-task test measured the ability to perform sixteen separate small Excel tasks. A whole-task test required learners to prepare a grade book different from the one they prepared in class. Finally, a transfer test asked learners to use Excel for an entirely new task—to prepare a budget. As you can see in Figure 15.8, both groups performed about the same on the part-task test. However, learners in the whole-task group did significantly better than learners in the part-task group on the grade book test, with an effect size of .71. Since the whole-task group had four opportunities to practice setting up a grade book compared to one opportunity in the part-task group, this is not a surprising outcome. The transfer test showed much better performance among the whole-task group than the part-task group, with a large effect size of 1.14. The research team points to the opportunities for varied context practice in the whole-task group, which may have helped these learners build a more flexible Excel skill set.

A lesson we can take from the Excel research is that well-designed whole-task learning may better prepare learners to apply new skills to different

Figure 15.8. Learning from Part- Versus Whole-Task Excel Lessons.
Based on data from Lim, Reiser, and Olina, 2009.



problems than those faced during training. Therefore, whole-task learning might be an effective design to achieve far-transfer learning goals.

A Summary of Evidence for Whole-Task Instruction

Taken together, there is mixed evidence regarding the benefits of a whole-task approach over a part-task design. Rather than compare whole-task designs with alternative designs, a more productive path is to (1) define the situations under which whole-task designs are more effective than part-task designs and (2) to isolate elements of whole-task designs requisite for optimal learning. Whole-task lessons may be best suited for more experienced learners who are not as easily overloaded and for learning of far transfer tasks that benefit from a more flexible mental model of the skills involved.

Thinking Skills Principle 3: Make Thinking Processes Explicit

Whether you adopt a part-task a whole-task or some combination design, it will be important to use instructional methods that make invisible thinking processes explicit. In BioWorld, for example, learners identify, post, and prioritize relevant evidence to support their diagnostic hypothesis. At the end of each case, they compare their evidence priorities with those of an expert.

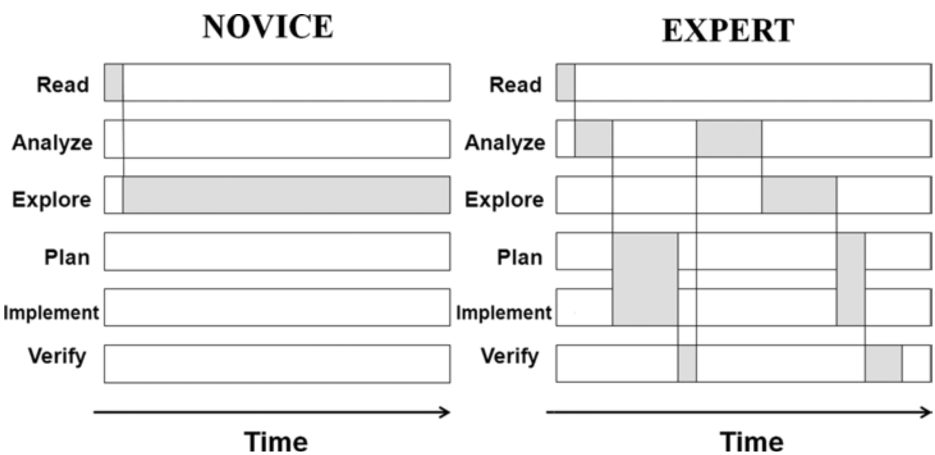
Effective problem-solving training must include both the cognitive *and* the thinking skills of the job—including approaches to creative, critical, and metacognitive thinking. Most job training today concentrates on knowledge of job facts, concepts, and procedures. The emphasis is on cognitive skills, along with associated knowledge. Rarely are the processes, especially the invisible mental processes involved in solving job problems, explicitly incorporated into the learning environment. For example, you may recall from your mathematics classes a focus on the calculation procedures needed to solve a problem. The mental processes underlying problem solution were typically not included. The result may have been that you knew what to do to solve a problem but you did not know when to do it or how to tell whether your approach was working.

Teach Metacognitive Skills

One important component of thinking involves planning, monitoring, and revising—in other words, metacognitive skills. In the last twenty years, educators have designed programs with the explicit goal of building metacognitive skills in their learners. Alan Schoenfeld, a mathematics professor, noted that his graduate students were quite adept at specific mathematical techniques taught in their classes, but they lacked problem-solving skills (1987). In studying the thinking processes of students, he noted that about 60 percent would read a problem, start down a solution path, and continue down that path, whether it was productive or not. Schoenfeld characterizes this as the "read the problem, make a decision to do something, and then pursue it come hell or high water" approach (p. 207). In contrast, experts solving the same problem were more reflective. In Figure 15.9 you can see Schoenfeld's visual representations of problem-solving activities of experts compared to novices. He gathered this data by recording and analyzing the dialog of experts and novices who talked aloud while they solved problems over a ten- to twenty-minute period. Unlike the novices who stuck to one approach, the expert problem solvers moved iteratively among planning, implementing, and evaluating problem-solving actions.

Figure 15.9. Different Problem-Solving Activities in Novice and Expert Mathematicians Over Time.

From Schoenfeld, 1987.



Schoenfeld designed training to help students build more expert-like problem-solving skills. He used worked examples and practice as his main instructional methods. He solved demonstration problems in class, during which he would voice aloud his thoughts—including his monitoring and adjusting thoughts. On occasion he might deliberately go down an unproductive path. After a bit he would stop and say something like, "Wait—is this getting me anywhere? What other alternatives might I consider?" In this way he provided examples not only of problem solutions but *also of the thinking processes* behind them. Second, he assigned problems to small student groups. As they worked together, he would visit the groups and ask "metacognitive questions" such as, "What are you doing now?" "Why are you trying that approach?" "What other approaches might you consider?" By first demonstrating and then holding learners responsible for applying these problem-solving process skills, they soon learned to incorporate this kind of thinking in their problem-solving sessions.

We recommend two techniques for making problem-solving processes explicit in e-learning:

- Engage learners with models of expert problem-solving actions and thinking.
- Require learners to interact not only to take the actions needed to resolve a problem but also to identify or generate the rationale behind those actions.

Display Expert Thinking Models

Similar to the Schoenfeld techniques described in the previous section, e-learning can make expert thinking processes explicit. Take a look at Figure 15.10 from our pharmaceutical consultative sales course. The sales expert is modeling the best responses to the physician's statements and questions. In this example, the learner can see into the expert's thinking process. The on-screen bubble displays her thoughts as she frames her answers. Pressing the "continue" button will display the remainder of the dialog. Expert thoughts could include consideration of alternative responses, as in this example, a rationale for a response, and/or responses to avoid.

Figure 15.10. The Thought Bubble Makes Expert Thinking Explicit.

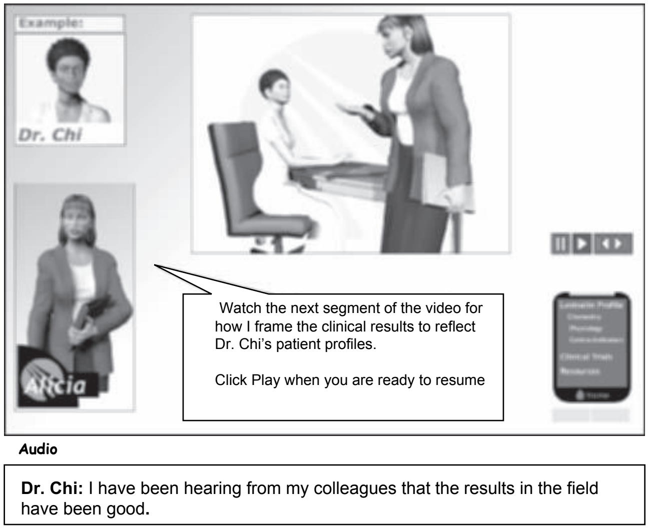
Audio

Alicia: Are many of your overweight and obese patients already taking weight-reducing drugs?
Dr. Chi: No, you see many of my patients can't afford expensive weight management drugs so I'm not sure how viable this drug is to my practice.

Focus Learner Attention to Behaviors of Expert Models

Moreno (2009) compared learning of teaching principles such as techniques to maintain attention, promote active learning, and prevent cognitive overload from animated teacher models that did or did not add focusing statements. Sixty-one student teachers were assigned to a multimedia lesson that explained teaching principles, followed by an animated classroom model of an expert teacher applying the principles. In one lesson version, a narrative statement from the teacher summarizing the principle to be shown in the animation was placed just prior to the scene modeling that principle. For example, "To maintain students' attention, I called them randomly by name though out the lesson" would be heard just prior to seeing the animated model calling on various students. The comparison lesson version used the same animation but omitted the focusing narration. Moreno (2009) found that the group lacking the focus statements took significantly longer to study the animated models and scored substantially lower on a transfer test. She concludes that "virtual classroom exemplars should be carefully designed to include narrated guidance that can help prospective teachers make

Figure 15.11. The Sales Representative Tells the Learner What to Watch for in the Video Example.



meaningful connections between the theory learned and the rich classroom information contained in the exemplars" (p. 499). In Figure 15.11 you can see how we applied this technique to our sales lesson.

Promote Active Observation of Expert Models

Van Gog, Sluijsmans, Joosten-ten Brinke, and Prins (2010) describe a pilot teacher-training online program in which learners select a professional situation such as handling groups of learners, conducting parental consultations, or asking effective questions. For each scenario reflecting a specific situation, learners are assigned to: observe, analyze, describe, and act. In the observe task, the learner watches a video example of a teacher responding to the situation and writes summaries of the main actions taken. The analyze task uses the same video but requires the learners to evaluate the actions they identified during the observation. For the describe task, learners observe the start of a new scenario related to the same professional situation and describe how they would respond. The learner receives feedback by comparing an expert response for the observation, analysis, and description assignments. The final act assignment requires the learner to respond to a similar situation on the job and receive feedback from a peer or mentor.

A lesson learned from the research on video modeling of teaching skills is that novices especially may not know where to direct their attention and may benefit from focusing guidance such as a statement just prior to the modeled behavior or a requirement to identify specific behaviors in the video.

Promote Learner Reflection on Their Own Thinking Processes

In e-learning you have some unique opportunities to provide learners with feedback on their problem-solving processes and promote reflection on those processes. For example, in Figure 15.5 an end-of-lesson screen from the troubleshooting lesson displays the path of the learner's testing actions next to those of an expert. By asking learners to articulate their own lessons learned from this type of comparison, a reflection assignment focuses on the problem-solving process—not just the final solution. In the same way, in BioWorld, as shown in Figure 15.6, the learner is asked to select a hypothesis and also to prioritize the evidence or the rationale for the hypothesis.

Thinking Skills Principle 4: Define Job-Specific Thinking Processes

As you plan e-learning to build problem-solving skills in your workforce, build in case scenarios, research tools, data sources, activities, and thinking processes that reflect job-specific expert approaches to problem resolution. You identify these job-specific thinking skills during the analysis phases of the design process. Because, when asked, most experts cannot articulate their rationale, you will often need to use special techniques called *cognitive task analysis* (CTA) to define the scenarios to be solved in the training as well as the thinking skills experts use to solve them.

In Table 15.2 we summarize a few different cognitive task analysis techniques. Which technique will work best for you will depend on the nature of the problems being solved as well as the work environment.

Table 15.2. Some Cognitive Task Analysis Methods.

Method	*Description*	*Tradeoffs*
Concurrent reporting	Subjects asked to verbalize all of their thoughts at the same time that they are solving a problem or working on a task	Not practical with verbal tasks such as sales Obtrusive May provide high amount of relevant data
Retrospective reporting	Subjects asked to verbalize all of their thoughts immediately or soon after solving a problem or working on a task	Relies on memory Unobtrusive
Cued retrospective reporting	Subjects asked to verbalize all of their thoughts after solving a problem or working on a task while viewing a record (video recording, eye-tracking data) of their work.	Provides memory support Obtrusive
Critical decision method	Expert identifies and reports on a past incident in which they solved a problem or worked on a task. Probing questions asked throughout several interview iterations.	Relies on memory Unobtrusive
Structured expert interview	Several experts independently describe three situations of diverse complexity in which they resolved a given professional situation and list the factors that influence their complexity rating. A consensus meeting identifies complexity factors and most appropriate response to situations.	Relies on memory Leverages multiple sources of expertise Unobtrusive

For example, concurrent reporting, which requires the workers to talk aloud while they resolve a task, cannot be used for a task that requires talking such as sales or customer service or for tasks that cannot be observed such as a combat situation. For tasks such as these, a retrospective approach that asks experts to later recall their actions and thoughts may be more appropriate. In the next paragraphs we summarize two cognitive task-analysis projects that relied on reflective interviews of experts describing problem situations they resolved in the past.

Two Cognitive Task Analysis Interviews

In one interview, Van Gog, Sluijsmans, Joosten-ten Brinke, and Prins (2010) summarize a method called structured expert sessions, used as the basis for the teacher training program described in the preceding section. To begin, a team of five to ten expert professionals is given a specific professional situation and each member individually describes from his or her own experience three specific instances of resolving that situation at different levels of complexity. For example, a team of five experienced teachers write out how they managed a parent-teacher conference. As part of the pre-work phase, each expert reviews her descriptions and abstracts specific factors that distinguish a less complex from a more complex situation. Following the pre-work, a team meeting of approximately two hours first gains agreement on the complexity factors, followed by consensus on the most appropriate actions to address situations that involve those factors.

In a second interview, Lajoie, Azevedo, and Fleiszer (1998) used expert interviews to plan an intensive care nursing problem-solving training. The development team interviewed three head nurses from the intensive care unit to determine the most difficult aspects of their jobs. These were used to define the job competencies that distinguish expert from beginning practitioners.

Following the interviews, the team worked with expert nurses to identify specific case problems that would incorporate those key competencies. Once some cases were developed on paper, the actions that experienced nurses would take to solve them were defined by asking three nurses unfamiliar with the case to talk aloud as they solved the problem. These problem-solving interviews followed a specific sequence. For every action that a nurse would mention, the interviewer would ask the reason for the action. Then the interviewer would state the outcome of the action and the respondent would state his or her interpretation of the outcome. The transcripts collected from these problem-solving sessions were coded into thinking skills categories, including hypothesis generation, planning of medical interventions, actions performed, results of evidence gathering, and interpretation of results, along with overall solution paths.

In summary, since expert job practitioners can rarely articulate their thinking process in a direct way, these must be inferred through a cognitive task analysis technique. Through the cognitive task analysis, you define: (1) scenarios to serve as learning cases, (2) criteria that distinguish scenarios of more or less complexity, (3) the normal tools and resources available to the worker, and (4) alternative solution paths and rationale.

Teaching Thinking Skills: The Bottom Line

In this chapter we have seen evidence and examples for the design of job-specific e-learning that builds thinking skills integrated with technical knowledge and skills. We suggest a domain- or job-specific approach that uses a real-world context for learning the thinking skills unique to a discipline. e-Learning offers: (1) unique opportunities to provide simulated experience in a compressed time frame and (2) a vehicle to make thinking processes explicit as well as to promote practice applying those skills.

Your training plan may reflect either a part-task or whole-task learning design. A part-task approach that ends with a case study might be appropriate for novice learners, who may be overloaded in a whole-task lesson. In contrast, a whole-task approach might benefit apprentice-level staff when effectively designed to offer a sequence of cases of increasing complexity with an appropriate level of learning support. With either design, keep in mind the considerable resources you will need to identify the relevant thinking and cognitive skills that will serve as the foundation for your program.

What We Don't Know About Teaching Thinking Skills

Based on evidence to date, we recommended some specific instructional approaches for helping learners build job-relevant thinking skills. However, many questions remain:

1. For what kinds of learners and work tasks will a whole-task versus a part-task learning design be most appropriate?
2. How can whole-task learning environments accommodate evolving expertise of a learner?
3. How will design of whole-task learning differ for relatively well structured problems such as automotive troubleshooting, compared to more open problems that have multiple approaches and solutions?
4. What is the potential return on investment (ROI) for the time invested in cognitive task analysis and design of thinking-skills e-learning? How will ROI be influenced by the stability of the cognitive and metacognitive skills involved?
5. How can cognitive load be best managed during whole-task learning?
6. How important is collaboration (among learners and between learners and instructors) to optimizing learning in whole-task problem solving environments?

DESIGN DILEMMA: RESOLVED

Your training department was charged with providing courses that would improve workforce thinking skills. In reviewing the many courses claiming to improve creative thinking, you wondered which of the following options were correct:

A. Money can be saved by purchasing an off-the-shelf course that includes techniques like the ones listed in Figure 15.1.

B. Thinking skills training would be most effective in a face-to-face environment.

C. Thinking skills training should be job specific; no one general thinking course will translate into improved workplace performance.

D. There is no way to improve thinking ability through training; it's like intelligence—you either have it or you don't.

Based on evidence to date, we believe that Option C offers the greatest promise for performance results from thinking skills training. However, this option requires customized training focusing on specific job-cognitive and metacognitive skills. Effective training may require considerable effort first to define the important thinking skills and then to create a learning environment to help learners acquire those skills.

To be most cost-effective, the training department might recommend a needs analysis to define which job roles involve thinking skills that most directly lead to organizational competitive advantage. Once identified, the complexity of problems involved in those roles and the stability of the underlying knowledge and skills should be evaluated. Such an analysis might help pinpoint work roles for which thinking skills training will give a maximum return on investment.

WHAT TO LOOK FOR IN e-LEARNING

- ☐ Lessons that allow learners to observe and apply job-specific thinking skills
- ☐ Interactions that require learners to make their reasoning process and products explicit
- ☐ Lessons that model thinking processes and assign practice that reflect expert strategies derived from cognitive task analysis
- ☐ Lessons that offer sufficient instructional guidance to ensure successful case resolution and learning of problem-solving skills
- ☐ Lessons that include several diverse problem scenarios to foster a more robust set of problem-solving skills

COMING NEXT

Games and simulations are one of the hottest topics in e-learning today. But before you jump on the bandwagon, you might wonder what evidence we have for the instructional value of games and simulations. In the next chapter we define the key elements of games and simulations, show some examples, and review what lessons we have learned from these environments so far.

Suggested Readings

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