How Instructional Design Experts Use Knowledge and Experience to Solve Ill-Structured Problems

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Abstract

This study examined how instructional design (ID) experts used their prior knowledge and previous experiences to solve an ill-structured instructional design problem. Seven experienced designers used a think-aloud procedure to articulate their problem-solving processes while reading a case narrative. Results, presented in the form of four assertions, showed that experts 1) narrowed the problem space by identifying key design challenges, 2) used an amalgamation of knowledge and experience to interpret the problem situation, 3) incorporated a mental model of the ID process in their problem analyses, and 4) came to similar conclusions about how to respond to the situation, despite differences in their initial conceptualizations. Implications for the education of novice instructional designers are discussed.

Experts in any field tend to be better problem solvers than novices. Faced with a problem situation, experts quickly form solutions that are more likely to be effective than solutions formed by novices. This characteristic of expertise has been documented in diverse domains: playing bridge (Charness, 1979), solving physics problems (Chi, Feltovich, & Glaser, 1981), repairing electrical generators (Jacobson, 1988), driving a taxi (Chase, 1983), and revising instructional text (LeMaistre, 1998). Experts are able to achieve this superior problem-solving performance, in large part, because they have at their disposals vast, well-organized stores of domain-specific knowledge, gained through extensive experience (Bruer, 1993; Glaser & Chi, 1988). Expertise is comprised of two major components: abstract knowledge and practical experiences (Bonner, 2007; Laurillard, 2002). While expert knowledge may arise from only one of these sources, both may be necessary to develop the kind of “fluid expertise” (Bereiter & Scardamalia, 1993) that allows individuals to adapt and apply their knowledge to novel situations. According to Bereiter and Scardamalia, practical experience by itself may lead to a kind of “crystallized expertise” that results in individuals who may not be particularly good problem solvers because they simply implement well-practiced procedures. In contrast, individuals with fluid expertise use both abstract knowledge and practical experience to think through a problem in a more dynamic and constructive way. While crystallized expertise would include the acquisition of automaticity after extensive practice in a relatively stable and constant system, fluid expertise would be characterized by flexibility that is responsive to changes in a dynamic world (Feltovich, Spiro, & Coulson, 1997).

Drawing on the expert-novice literature, Ertmer and Stepich (2005) outlined six dimensions that characterize the problem solving processes of expert instructional designers. Central among these dimensions is the expert’s ability to “synthesize” a particular problem situation; that is, to formulate a clear, coherent representation in terms of one or two central issues. This kind of synthesizing has been a recognized aspect of expert practice for a
long time. For example, Larkin, McDermott, Simon, and Simon (1980) found that physics experts routinely generated a physical representation of the problem situation before attempting a computational solution. More specifically, when experts were given complex problems to solve, they frequently began by drawing a sketch of the central elements of the problem. This physical representation reduced the problem space, allowing the experts to identify relevant variables and test relevant qualitative hypotheses. Once these hypotheses were checked, the experts would fill in the details and solve the problem quantitatively. In the nursing field, Benner (1984) used the term “recognitional ability” to describe the ability of expert nurses to discriminate relevant from irrelevant information and to develop a context-dependent, holistic perceptual understanding of the patient situation. According to Benner, this ability is based on collected practical experiences that expert nurses use to continually refine their abstract knowledge. In both cases, the authors suggested that experts begin the problem solving process by developing a “big picture” understanding of the problem situation.

Similar results have been shown within the field of instructional design. For example, Perez and Emery (1995) asked expert and novice instructional designers to design a computer simulation on diesel engine mechanics. They found that experts were more likely to identify a central element of the problem (e.g., the characteristics of the target audience) and to return to this element as they began to work out the design details. Perez and Emery referred to this approach as a “breadth-first, top-down, progressive” design strategy. In another study involving the revision of instructional text (LeMaistre, 1998), the expert instructional designer initially identified the lack of overall structure of the text as the primary problem and continually referred to the importance of structure throughout the revision process. LeMaistre noted that the expert was explicit in the creation of the problem space and employed “strategies of constantly adjusting decisions and decomposing the problem into manageable parts” (p. 31) so that related aspects of the problem could be addressed collectively rather than in an isolated fashion.

While it seems clear that experts engage in the kind of synthesizing described above, it is less clear how this process is influenced by the experts’ vast stores of knowledge. Building on the idea that expert knowledge is made up of abstract knowledge and practical experience, one view is that synthesizing is based, primarily, on the recall of abstract knowledge. In this view, experts define a problem in terms of conceptual principles drawn from their stores of domain knowledge (Ertmer & Stepich, 2005). For example, Chi et al. (1981) asked experts and novices to outline solutions to physics problems. While novices typically defined the problem in terms of literal objects and terminology used in the problem statement, experts were more likely to identify a “second order feature,” referring to a feature that was not explicitly described in the problem statement, but that was derived from a small piece of given information that activated a relevant schema in the experts’ existing knowledge. Glaser and Chi (1988) noted that, with experience, experts encode not only the procedures for solving relevant problems but also the conditions under which they are applied.

An alternative view is that synthesizing is based, primarily, on the recall of practical experiences. In this view, experts define a problem in terms of a similar situation drawn from prior experiences (i.e., a case). For example, Rowland (1992) found that instructional design experts typically associated a given situation with similar problems they had previously encountered and used those prior experiences to develop an initial picture of the current problem and how it might be solved. Similarly, Perez, Jacobson, and Emery (1995) observed that instructional design experts often reflected on past design problems and solutions and compared them with the problems at hand. Klein and Calderwood (1988) studied decision making among urban fire commanders, wild land incident commanders, and tank platoon commanders and found that these individuals based their decision making more on prior cases than abstract principles. This interpretation is supported further by research on case-based reasoning (Kolodner, 1997), which posits that experts have amassed rich libraries of case experiences that they apply, through a type of analogical reasoning, when solving new problems.

To elaborate, case-based reasoning is defined as “solving a new problem by remembering a previous similar situation and by reusing information and knowledge of that situation” (Aamodt & Plaza, 1996, p. 40). Theorists claim that human reasoning is case-based; that is, we all have different experiences that are stored in our memories and then reused when new problems trigger the recall of similar situations (Kolodner, 1993; Schank, 1999). Jonassen and Hernandez-Serrano (2002), after reviewing studies in multiple contexts, proposed that “experts relied more heavily on cases based on past experience than on abstract principles when making decisions with a high degree of uncertainty” (p. 68). They argued that cases and stories work more effectively than abstract rules or principles in knowledge construction because they “require less cognitive effort than exposition” (p. 66). Moreover, stories or cases facilitate vicarious learning by providing a substitute for first-hand experience (Jonassen, 1999).

Although these two explanations of synthesizing appear conflicting, they may not be mutually exclusive. For example, Genberg (1992) suggested that expertise might be viewed from two different lenses: 1) an information-processing lens and 2) an intuitive lens. While the former emphasizes the organization of knowledge and the progression of skill acquisition, the latter focuses on the relevance of past experiences in a particular context.
Kolodner and Guzdial (1999), while strong advocates of reasoning from cases, stressed that abstraction is necessary for organizing, or indexing, cases within one’s library, as well as for efficient retrieval. In other words, experts seem to extract guidelines and principles from concrete experiences that they then apply to new problem solving situations. This idea is supported further by research by Didierjean and Cauzinille-Marmeche (1998) who demonstrated that individuals can develop, and even use simultaneously, these two types of reasoning processes.

Purpose

The purpose of this study was to determine if instructional design (ID) experts synthesized the issues presented in an ill-structured problem scenario (as described in the literature), and if so, how abstract knowledge and practical experience were used during the synthesizing process. Based on the six dimensions of expert thinking described by Ertmer and Stepich (2005), we selected synthesizing, a critical characteristic that distinguishes experts from novices, to further our understanding of how experts use their prior knowledge of rules and principles, and/or draw upon their previous experiences.

Method

Overview

This study was designed to examine the processes that experienced instructional designers use when solving ill-defined instructional design problems. Data consisted of a demographic survey, think-aloud protocols, and interviews with seven participants. The think-aloud protocols captured experts’ verbalizations during the problem-solving process and the interviews gathered additional data about how experience and knowledge were used during the process.

Theoretical Framework

We used grounded theory, a method of qualitative inquiry designed to generate an explanatory theory of a specific process or phenomenon (Glaser & Strauss, 1967; Strauss & Corbin, 1997). Grounded theory is an inductive approach in which theory is derived from the data through a process of asking questions and making comparisons. The primary objective is to expand upon an explanation of a phenomenon by identifying the key elements and the relationships among them within the specific context of the research study (Davidson, 2002). Thus, in this study, a grounded theory approach enabled us to develop a theoretical account of the characteristics of expert problem solving while simultaneously grounding the account in empirical data (Strauss & Corbin, 1997).

Role of Researchers

This study was designed and implemented by a research team consisting of six doctoral students and one faculty member at a large mid-western university. A second faculty member, located at a large western university, acted as a consultant to the team during the design and implementation of the study. All but one student had previously completed an advanced instructional design course, which utilized ill-defined case problems. Students had a range of previous ID experiences in both educational and business contexts.

Prior to the start of the study, a pilot was conducted with one participant, during which the entire research team observed and/or participated in implementing the data collection procedures. Subsequently, the research team divided into two subgroups with each group taking primary responsibility for conducting the research with three of the six remaining participants. As a team, students worked to define the research protocol, to modify specific data collection procedures that were either problematic or unclear during the pilot, and to clarify each person’s role in the subgroups. The researchers carefully checked and monitored each other during the entire research process, reviewing transcriptions for accuracy and requiring clear evidence of initial interpretations. For example, specific claims were linked to supporting data (using a line-numbering system for each transcription), thus enabling team members to challenge or support initial interpretations and to provide either additional or counter evidence.

Participants

Seven expert instructional designers (four women and three men) were purposefully selected. Each participant had eight or more years of instructional design experience, in a variety of settings. Demographic data
On average, participants had 20.5 years of instructional design experience, ranging from 8 to 32 years. Four participants were currently working in higher education (with two of these holding a Ph. D. degree), while three were employed in the business sector. All seven designers indicated that they regularly participated in all aspects of the instructional design process (analysis, design, development, implementation, evaluation). In addition, six of the seven participants indicated that they had previous experience with face-to-face, computer-based, online, self-instructional, and hybrid instructional delivery formats.

Data Collection

Following the completion of the demographic survey, participants met individually with one of the two research subgroups to participate in a think-aloud process in which they read and reflected on an ill-defined instructional design problem. The problem (Hooper & Doering, 2007) was presented via a 12 page, double-spaced, typed narrative and dealt with the topic of converting a face-to-face HIV/AIDS workshop to an online format — a topic for which none of the participants had previously developed instruction. Each data collection session lasted about two hours and included a warm-up exercise, the think-aloud procedure, and a retrospective interview. The warm-up exercise included a small problem that the participants used to practice the think-aloud approach (e.g., identify the number of windows in your house). Retrospective interviewing (Ericsson & Simon, 1980) occurred immediately after the think aloud as a way to help participants reflect on, and verbalize, their thought processes during the think aloud, drawing from both long- and short-term memory (e.g., Describe the method you used to determine the number of windows in your house.). In addition, interviews included questions to clarify comments participants made during the process and to explicate how knowledge and experiences were used. The interviews included questions such as, “What was the first thing you thought about as you read the case?” “What made you think of that?” or “Where did you learn that?” All sessions were videotaped and transcribed.

Data Analysis

Transcriptions were examined using a constant comparison method, with specific attention given to participants’ references to prior knowledge and experiences. Initially, each researcher conducted an analysis of a single transcription, looking for evidence that related to our two research questions, but without establishing preconceived ideas about what might be discovered. This resulted in a set of tentative profiles that captured each participant’s response to the case situation. Following this, two researchers applied a modified open-coding process using an electronic copy of each transcription, inserting comments and highlighting quotes that seemed particularly relevant to our questions. However, rather than create a set of categories and subcategories as is typical in open coding (Creswell, 2003), we created a set of themes that reflected each participant’s responses. Themes for each participant were shared and discussed between the two researchers as they were developed. During these conversations, no attempts were made to come to consensus, but merely to note the similarities among the themes and to seek clarification and additional evidence if the interpretations were unique or unusual.

After creating themes for each participant, the researchers then looked for similarities across participants as the first step in creating a set of assertions that could be applied to the majority, if not all, of our participants. If the themes were not evident among at least four participants, they were not used in the final set of assertions. Finally, after the assertions were developed, they were presented to the rest of the research team (with evidence) for additional comment and final team verification. The team then worked together to find relevant supporting or contradictory evidence from the literature.

Validity/Reliability

Lincoln and Guba (1985) recommended that qualitative results be evaluated using the standard of “trustworthiness,” as established by credibility and confirmability. In this study, credibility was gained though triangulation of multiple data sources including a demographic survey, think-aloud protocol, and retrospective interview. The use of multiple researchers led to confirmability of the data. Throughout the study, weekly meetings of the researchers helped to ensure understanding of our research questions, consistency of data collection, and interpretations of data. Data analysis involved both individual and collaborative efforts in order to develop and verify the emergent themes and overall assertions. A line numbering system was used to identify specific data supporting each finding, thus creating a traceable link between evidence and assertions. Finally, participants verified our interpretations, immediately during the interviews, and later through their responses to specific email queries.
Results and Discussion

In this study we asked questions about how experts used their knowledge and experience to solve ill-structured problems presented via a case study narrative. We present our findings in the form of four assertions that were developed through our analysis and interpretation of the data. Excerpts from the participants’ think-aloud and interview protocols are integrated with interpretive commentary to support each assertion. Subsequently, we discuss how each assertion is, or is not, supported by the literature.

**Assertion 1.** In identifying the key design challenges, experts narrowed the problem space. For some, this seemed to occur either in place of, or prior to, making a synthesis statement. According to the literature, a major task of the problem-solving process involves “being able to articulate a clear and concise representation of the problem(s) in a particular situation” (Ertmer & Stepich, 2005, p. 39). Referring to this as the ability to “synthesize” the issues in a problem situation, the authors noted that this is a key characteristic of expert instructional designers.

In this study, all seven participants articulated specific design challenges related to converting a highly interactive face-to-face workshop to an online format. Specific aspects of the case situation were highlighted either because they were seen as particularly central to the effectiveness of the workshop and/or particularly difficult to translate to an online environment. For example, as Jacob read the sentence, “Experiences were extremely powerful” he stopped and added “which is going to be wonderfully fun to try to do with the Internet.” Similarly, when Marlene read the sentence, “The face-to-face … workshop was presented to approximately 50-60 participants who traveled to a single location and met for approximately 16 hours over a two-day period,” she noted, “That seems problematic to me, for something that’s online.” Additional challenges highlighted by the participants included, among others: the importance of interactions among the workshop participants, learning by doing, resolving access issues, facilitating and maintaining behavior change advocated by the workshop leaders, and “smoothing out” interpersonal relationships among the designers in the case (described in more detail in Assertion 4).

Among our seven participants, “highlighting” seemed to be more common than “synthesizing.” Despite the fact that every participant articulated specific challenges related to converting the face-to-face workshop to an online format, not every participant synthesized these challenges into a clear concise statement, as hypothesized earlier. While Jacob, for example, stated the problem in a very straightforward manner (“I see the problem as determining what are the essential characteristics to changing behavior?”), others simply pointed out a number of different elements that would be difficult to transfer to the online environment without making a direct statement about how these elements contributed to, or comprised, the core problem. For example, as Jill engaged in the think-aloud process, she stopped periodically to comment on new challenges as they were introduced in the case narrative. These challenges related to a wide variety of issues: putting an interactive workshop online, moderating discussions, providing appropriate counseling services, securing online permissions, resolving access issues, and limiting the amount of time required. Jill noted that she usually begins the design process by “looking for some sort of initial analysis, starting with some kind of objectives” but because these were not immediately available, she described her approach as just “kind of reacting to things as we went through.” This lack of a synthesis statement, then, may have been due to a stylistic difference among participants or to a variation in the way the researchers asked the participants to state the problem. Alternatively, it may suggest that synthesizing does not always result in a single concise statement of the problem. Instead, as Gredler (2004) suggested, experts may identify key information within a situation and use that information to create a mental map of the problem.

In almost all instances in which synthesizing occurred, it was preceded by highlighting. Most often, the synthesis statement captured one or two key design challenges that the participants had highlighted during the think-aloud process. For example, after highlighting a number of problem elements, Simone stated:

If that data is [sic] actually true and correct, I’d want to hone in on what elements of instruction itself—the format, the instruction, the affective aspect of it, group interaction [all problem elements noted earlier]—all of that and say, “What part of this made it the most successful?” and “Can this be duplicated?”

As another example, after mentioning a number of potential problem elements, Thad synthesized the issues with the following statement:

Soon you’re going to have some kind of table [in which] you compare what they’ve done in the past, and if it worked then, are you going to be able to transfer that over into the online environment and help them to solve some problems they are having in the transfer? That’s probably where they are having their most difficulty in creating this thing, is that transfer of some of these things.

The literature suggests that experts tend to translate ill-defined or unfamiliar problems into well-defined or more familiar problems as a way to narrow the problem space and search for a solution (Glaser & Chi, 1988;
According to Rowland (1992), expert designers approach new problem situations using existing “frames of reference,” built from their previous knowledge and experiences. Frames of reference, then, may be one way in which experts make this translation from an ill-defined problem to a more defined one. Similar to what Rowland (1992) and Perez and Niederman (1992) found, each participant in this study understood the case problem in terms of the personal experiences and perspectives s/he brought to the case as much as by the information provided by the case narrative. For example, based on her 22 years of experience as a designer in business and industry, Marlene brought a “training” frame of reference to the problem: “What is the problem? Will training address it? Who are we dealing with?” She elaborated on her specific perspective:

I look at it from a training perspective and then I add all of the human baggage that goes with it, or that is going on there. I go to “what is the target audience” and get a clear definition of what that is. And then [I get] a clear definition of what the training issues are by defining the objectives.

Sean, who had a background in counseling psychology used a “consulting” perspective: “The problem is more about the interaction of the cultural differences between the organizations as much as it’s about a lack of specificity of the goals.” As he explained further:

This is a very typical problem … it’s a challenge for consultants who work with the military, for example. And I was sort of thinking that as one of my frames of reference. I have experience in that. I do my research with consultants as well and … there is always tension between research design and product design.

In contrast, Sammie used her communication background to frame the problem in terms of the type of topic that needed to be addressed and the kinds of conversations that needed to occur: “With such a … touchy topic, I would want to have control in the room so if something happened I would be there to handle it, … I have a background in communications and all of my teaching is done in very small groups where I can watch the faces of my students and especially their non-verbal behavior and make instant corrections in the instruction.”

As a final example, Jacob, who was in charge of instructional computing on a large university campus, used an administrative perspective to consider whether the “real” problem could be addressed in an online environment: “I pull from components of projects and they are kind of reorganized into other types of situations. I’m primarily an administrator, so my categories right now are: project timelines, budgets, legal, those types of things.”

In summary, participants in this study all identified multiple design challenges in the case scenario, with these challenges later being combined, by five of the seven participants, into the articulation of a synthesis statement during the interview process. As suggested by Schon (1983), the first step in the problem solving process is problem finding or problem setting: “The designer must make sense of an uncertain situation that initially makes no sense” (p. 74). As part of this process, expert designers identify the constraints, or problem elements, of the given situation. Goel and Pirolli (1992) suggested that during this process, expert designers may explicitly try to change the problem situation so it more closely matches their personal expertise and knowledge. Although we didn’t observe our participants use their frames of reference to actually transform the case information, they were employed to filter through the details, facilitating a focus on those case details that were judged most critical.

Assertion 2. When analyzing ill-structured problems presented via a case narrative, instructional design experts used an amalgamation of knowledge and experience. While all of our participants referred to specific prior experiences and six of seven referred to some specific piece of abstract, academic knowledge (e.g., ADDIE model, Gagne’s types of learning, message design), their interpretations of the case details relied primarily on an amalgamation, or blend, of knowledge and experience. When asked, specifically, how they knew to use a particular strategy or to consider particular issues, our participants typically referred to previous experiences. For example, Marlene responded, “How do I know that? I know that just from my experiences working in this company,” while Simone reflected, “I’m thinking of my own experiences with taking online courses.” Sean captured the general feeling of all of our participants when he stated, “I have been in that situation many times.”

In general, the recollection of specific ID experiences or specific ID principles was rare. Furthermore, if participants recalled specific experiences, they didn’t really use the information from that experience to narrow the problem space or solve the problem (at least not in any obvious way). If they recalled specific book knowledge, it was usually embedded within their recall of experiences. More typically, the participants recalled a “mix” or “blend” of experiences that were relevant to the current problem. Consider the following quotes from three participants:

- “I can’t say, oh this really reminds me of this, but there is … all the little pieces remind me of something.” (Jill)
- “I’m thinking it was background experiences but there isn’t one specific one.” (Thad)
- “I have a blend in my head that is from many different experiences … in my mind, it just all blends together … I pull from components of projects, and they are kind of re-categorized into other types of situations.” (Jacob)

LeMaistre, 1998; Perez et al., 1995).
Rather than accessing a single specific prior experience (a case), participants extracted from their collected experiences one or more relevant rules, which they applied to the current situation. These rules were not ones that could be found in an ID textbook, but were much more idiosyncratic and were drawn from the unique collection of previous experiences that each participant brought to the current situation (Klein & Calderwood, 1988; Kolodner & Guzdial, 1999). According to Davenport and Prusak (2000), rules of thumb are “guides to action” that have developed over time through extensive experience and observation (p. 10). Schank (cited in Davenport & Prusak) referred to these internalized responses as “scripts,” which, like play scripts or computer programming codes, act as efficient guides to complex situations, offering plausible routes through a maze of alternative solutions (p. 11).

As an example of how our participants applied rules of thumb during their analyses of the case narrative, Thad suggested that before you can decide what to translate to an online environment you need to know exactly what’s making the current materials effective. This rule is captured in his comment: “You have to take it [the workshop] apart and make sure that the type of thing isn’t going on where you think it is effective, but yet it really wasn’t teaching what they needed.” As another example, Sammie used a set of rules to guide her decision-making that related to her background in communication. These rules helped her decide how to handle sensitive topics in a workshop environment: “If [the workshop involves] interaction and the subject is controversial, the delivery should be face-to-face.” For Sammie, the decision to keep the workshop face-to-face appeared to be based on what she viewed as a critical rule of thumb. Similarly, a related rule was captured when she stated, “If it’s a run-of-the-mill topic, then it could be successfully converted to the Internet.”

In summary, experts in this study used an amalgamation of knowledge and experience to analyze the problem situation presented in the case narrative. Similar to what Davenport and Prusak (2000) described as a “fluid mix of framed experience” (p. 5), our participants appeared to access domain-specific knowledge, which was built of experience. As noted by Kolodner (1988; 1997), expert problem solvers tend to access their case memories multiple times during a problem-solving episode, thus allowing them to recall several cases (previous experiences), rather than just one, to be used during the process. Results from this study support this contention.

**Assertion 3.** When recalling previous ID knowledge and experiences to solve an ill-structured problem, ID experts accessed a mental model of the instructional design process to guide their thinking. According to the literature, experts have a large store of organized domain-specific knowledge (Bransford, Brown, & Cocking, 2000; Bruer, 1993; Glaser & Chi, 1988), organized as schemas or deep knowledge structures (Bedard & Chi, 1992; Brophy, Hodge, & Bransford, 2004). Johnson (1988) suggested that expert knowledge is organized schematically as a mental model of the relevant system. Experts use this mental model, then, to create a large-scale, qualitative representation of the current problem (Larkin et. al., 1980) as a first step in solving the problem.

In this study, all seven of our participants made statements suggesting that they approached the case with some kind of instructional design process model in mind. The models varied, but everyone had one. Two types of models accounted for six of the seven experts in this study. For example, three of the participants used an “audience first” model:

- “The first thing I like to do is write down what the target audience is.” (Marlene)
- “You need to know what the audience is and the more you know about the audience the better you can design something.” (Sammie)
- “OK, so I’m honing in on the target audience because any time you design instruction you are designing it for a particular audience and it is helpful to know who that audience is and as much information as possible about that audience.” (Simone)

Three of the remaining four participants used an “outcomes first” model. This shows up, specifically, in comments about what is missing in the case:

- “… a lot of the objectives are not clear to me. So, I’d really want to nail it down first of all.” (Jill)
- “What are the objectives here? … These are goals, they’re not objectives – they’re way too broad.” (Jacob)
- “As a designer, the challenge here is figuring out the complex combination of learning outcomes that they are after … thinking about a solution is way too far down the road because we don’t know what the goal is.” (Sean)

Finally, one participant used a “domains of learning first” model. A critical step in Thad’s process was to “classify the type of learning that is occurring.” In contrast to other experts, Thad did not refer to objectives or goals. Instead, he referred to the type of learning, specifically questioning whether the focus of the workshop was on verbal information or attitudes and noting that “we’ve got to go at it a little different” depending on the type of learning.
involved. This idea of domain-specific instructional strategies is a central principle in Gagne’s instructional design model, which suggests that Thad’s mental model was based on Gagne’s theory.

In general, our participants used these mental models to guide their thinking about the case. Typically, they did not follow their models on a 1 to 1 basis, like a recipe. Instead, they used their models in a broader, more heuristic way. While the nature of the think-aloud task may have limited their uses of the model to the beginning stages of the analysis task, our participants appeared to apply them in two explicit ways: 1) to structure their searches for information, as illustrated by Marlene and Simone, respectively (“I needed to look for information to fit into a model like the ADDIE model.” “… The ADDIE Model is just sort of a nice little acronym that reminds me have you covered all of these bases. It may not be in that order necessarily in reality.”), and 2) to focus their attention on initial information considered critical to the instructional design process. This isn’t necessarily the first step in a particular textbook model, but rather the element of the ID process that the experts saw as particularly critical at the start of the process. For example:

- Sammie (“audience first”) focused first on the needs of the target audience.
- Jacob (“objectives first”) distinguished between objectives and goals and wanted to know what the objectives were. It’s worth noting that objectives are not the first consideration in the Dick and Carey model (the textbook model that Jacob mentioned), which supports the idea that the mental models were individual heuristics rather than textbook-based recipes.
- Thad (“domains of learning first”) based his thoughts about selecting the instructional media on the type of learning involved.

The fact that our designers all accessed a mental model of the ID process is not surprising, as it is supported by the literature. Recent research by Campbell, Schwier, and Kenny (2006) suggested that designers reference conventional ID processes in their conversations about design, although their practice varies significantly according to context. Perez and Neiderman (1992) also reported that the experts in their study used a design process that reflected a systems approach, yet varied in how they implemented the process. The authors argued that these differences were related to the frames of reference that the experts used when making their design decisions. Again, this may explain why our participants used the models that they did: that is, an “audience first” model was more compatible with a communications frame of reference, while an “outcomes first” model was more compatible with an administrator’s frame of reference. After participating in a large number of relevant projects, the mental models of the ID process enabled our experts to reason, not from textbook principles or models, but rather from “first principles” (Merrill, 2002; Reigeluth, 1997; Winn, 1997). This is similar to what other researchers have described: Experts tend to look past the surface details in a problem to focus on the underlying principles or “big ideas” embedded in the situation (Bransford et al., 2000; Glaser & Chi, 1988; Larkin et al., 1980).

Mental models are one characteristic that have been used to distinguish between expert and novice designers. In general, novice designers have access, primarily, to textbook models, which don’t necessarily apply to novel problem situations (Atherton, 2002; Reimann & Schult, 1996). In contrast, based on their many years of experience in a variety of contexts, experts are able to recognize patterns of practice and generate solutions based on those that have worked in similar situations (Hardre, Ge, & Thomas, 2006; Kirschner, Sweller, & Clark, 2006).

**Assertion 4.** The experts came to the same, or a very similar, conclusion about how to respond to the situation. Polya (cited in Wilson, 1997) stated that once we’ve figured out how to see a problem in a certain way, the solution becomes obvious (p. 23). Given that the frames of reference used by our participants all incorporated some variation of an ID process model, (Assertion 3) this may explain why (and how) the experts in our study all came to see the design problem in a similar way. As captured by Assertion 1, all seven participants articulated explicit design challenges related to converting the face-to-face workshop to an online format. Specifically, as illustrated by Table 1, the participants mainly focused on four related issues: the affective nature of the workshop, the use of diverse instructional strategies, achieving the goal of behavior change, and the interactive nature of the workshop.

Table 1. Design Challenges Identified by Participants

<table>
<thead>
<tr>
<th>Identified design challenges</th>
<th>Jacob</th>
<th>Jill</th>
<th>Marlene</th>
<th>Sammie</th>
<th>Simone</th>
<th>Sean</th>
<th>Thad</th>
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<td>The affective nature of the workshop (e.g., powerful experiences, intense engagement)</td>
<td>x</td>
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<td>Converting the instructional strategies that were effective in the F2F workshop to an online format</td>
<td>x</td>
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The results of this study suggest that expert designers, despite some variation in their conceptualizations of the issues in the problem situation, still reach similar conclusions about how to address those issues. This finding is similar to that of Spector and Koszalka (2004) who found that experts conceptualize complex problems in recognizably similar ways. As pointed out by Driscoll and Carliner (2005), this may relate to the nature of the problem-finding process in that early problem identification subsequently limits the number of solution paths that can be considered. It is conceivable that by initially highlighting similar elements, our designers had, in effect, constrained the number of possible solution paths. However, this finding contrasts with what Rowland (1992) reported in his study, in which the experts were described as demonstrating a “significant amount of variation” (p. 81), both in terms of their problem representations and proposed solutions. Rowland attributed this result to the different frames of reference used by his participants. While no two designers in our study appeared to use the same frame of reference when analyzing the problem, they all incorporated key elements of the design process within those frames, a similarity that was not described by Rowland. Perhaps, the “significant” variation in initial problem representation left more solution paths open for Rowland’s participants to explore. Finally, we must also consider the simple explanation that the case narrative used in this study was not as complex as the problem that Rowland’s experts encountered, thus allowing our experts to more readily represent and address the core issues in similar ways. As another point of contrast, the specific problem presented to the experts in this study required only that they “translate” existing instruction to a new format, rather than “design” something new from scratch. Additional research is needed to help clarify these seemingly conflicting results.
Implications for the Education of Designers

The results of this study have implications for the education of instructional designers. First, the results support findings from previous research (LeMaistre, 1998; Perez & Emery, 1995) that suggest that ID experts construct a clear understanding of the issues in an ill-structured problem as the first step in the problem-solving process. While two of our experts did not specifically articulate a synthesis statement, they all narrowed the problem space by identifying key problem elements in the case narrative. It is possible that, with practice and support, novices also can learn to do this effectively. This idea is supported by findings from Dufresne, Gerace, Hardiman, and Mestre (1992) who taught students to solve physics problems using a computer-based “Hierarchical Analysis Tool” (HAT) that prompted them to analyze the problem in more expert-like ways. In subsequent problem-solving exercises, students who received the HAT instruction were noted to use the expert-like strategy more often than students who received other types of instruction. That is, by using a hierarchical analysis structure that integrated concepts, principles, and procedures, novices were able to increase their focus on the deep structure of the problem rather than on surface details. A similar approach may be used with ID novices who could be given analysis guidelines that compel them to consider “big picture” (as opposed to surface) issues when analyzing ill-structured problems. Preliminary results from a study by Author (in progress) suggest that the use of guidelines or scaffolds that remind novices to, among other things, 1) focus on the “big picture,” 2) consider the core issues (i.e., those that are most central to understanding the case), and 3) consider the critical issues (i.e., those that are most likely to lead to a successful resolution), helped them analyze an ill-structured case scenario in more expert-like ways than novices who were not given these guidelines. Additional research is needed to verify these preliminary results.

The experts in this study appeared to use personal frames of reference, based on accumulated sets of previous experiences, when conceptualizing the ID challenges embedded within a problem scenario. While it is unlikely that ID students will have amassed many personal experiences (related to ID practice) while still in school, there is some indication that students can benefit, vicariously, from the experiences of others (Jonassen, 1999; Schon, 1993). Fortunately, there are a variety of ways to incorporate both direct and vicarious learning experiences into our graduate programs including the use of case studies; internship and practicum experiences; guest speakers; as well as consulting with, and working for, real clients as part of a studio design approach. This is in line with Collins’ (1991) recommendations for designing cognitive apprenticeships, which suggest that novices observe experts as they solve problems so they can witness the false starts and dead-ends that are typical of real-world problem solving. Furthermore, by hearing experts’ reflections-in-action (Schon, 1993), novices may gain deeper understanding of the entire problem-solving process. So, for example, if students were to view videotapes of experts as they analyzed ill-structured case studies, they would not only see real-world examples of completed analyses, but also hear how the experts arrived at their final solutions. Furthermore, students could compare their ideas about the case with those of experts, providing rich fodder for meaningful reflection. Each of these strategies could provide opportunities for novices to hear and benefit from the experiences of more expert others.

Still, it may be important to help students index these experiences in ways that are readily retrievable (Kolodner, Owensby, & Guzdial, 2004). According to Jonassen and Hernandez-Serrano (2002), the ability to recall prior experiences depends on how those experiences are stored in memory. Aamodt and Plaza (1994) noted that effective case-based reasoning requires a “well thought out set of methods” (p. 41) for indexing cases/experiences so they can be readily integrated into existing knowledge and then easily retrieved when needed to solve similar problems. Since only a subset of one’s knowledge and/or experience will be relevant to any single problem, a practitioner needs to be able to select and retrieve only that which is relevant. Part of the job of the ID educator, then, becomes that of supporting novices as they observe, accumulate, and store (in memory) relevant experiences during their graduate programs.

Providing appropriate learning experiences may be part of the answer, but it is also important to help students reflect on those experiences in ways that enable them to readily recall and use those experiences during future problem solving situations. For example, case study discussions can focus students’ attention on specific problem elements and design challenges in the case, as well as possible solutions and their implications. Following this, Didierjean and Cauzinille-Marmeche (1998) recommended that we help students represent the knowledge gained at multiple levels of abstraction. At the lowest level, this would entail simply storing / indexing “unabstracted” knowledge in the form of specific case details (e.g., context, stakeholders, events). At the next level, case details would be represented in the form of themes or concepts underlying the specifics (e.g., communication issues, project management decisions). Further abstraction might result in the formation of a principle, or rule of thumb, that links the concepts or themes through causal, correlational, or chronological relationships (e.g., “If the subject is controversial, the delivery should be face-to-face; if it’s a run-of-the-mill topic, it could be converted to the Internet.”). As students’ case knowledge becomes more abstract, it would have the potential to be more
generalizable. However, it also would lose the local and specific nuances that would enable it to address novelties, ambiguities, and exceptions to the generalities (Didierjean & Cauzinille-Marmeche, 1998; Reimann & Schult, 1996). Ideally, students would integrate their knowledge across all levels of abstraction to enable the most effective reasoning and recall. As students’ mental models became more sophisticated through each subsequent experience, they would, over time, increase their ability to identify the underlying structure of the problem situation and thus reason from first principles (Reigeluth, 1997).

Limitations and Suggestions for Future Research

In addition to the small number of participants, a primary limitation of this study relates to the use of think-aloud protocols for data collection. While this is a common approach used in expert-novice studies (LeMaistre, 1998; Perez & Emery, 1995; Rowland, 1992), some participants are better at engaging in the concurrent tasks of problem solving and thinking aloud than others. In this study, this may have been complicated further by the manner in which the design problem was presented to the participants, that is, as a text-based case narrative. Asking participants to think-aloud as they read the case out loud may have interfered with their normal problem solving processes. Furthermore, according to Lloyd, Lawson, and Sean (1995), protocol analysis itself may interfere with designing and thus not accurately represent the design thinking we are trying to analyze. Additional research is needed to determine the extent of the influence of a think-aloud procedure on design thinking, as well as to evaluate other means for capturing the thought processes of experts. For example, it may be possible to videotape a team of designers as they discuss a novel case, capturing their conversations, and thus their thinking, as they analyze the situation. Another option might be to present the case situation via video rather than print, perhaps enabling a different type of thought process than that captured by reading and thinking-aloud. Finally, asking individuals to write a synopsis of a case situation might be able to capture important components of the problem-solving process, such as initial design decisions or elements deemed critical by the designer. While each of these methods has advantages and limitations, it also may be possible to combine approaches to adequately address critical shortcomings. This area appears ripe for additional research.

While this study focused primarily on experts’ approaches to analysis (problem-finding), it will be important also to look at experts’ approaches to designing solutions to the problems identified. Although all of the participants in this study made some suggestions about how to solve the problems described in the case, this was not pursued in depth due to time constraints. Future research should examine how experts use their previous knowledge and experiences to design solutions to ill-structured problems, including the extent to which they apply personal rules of thumb as they did during the problem finding process.

Conclusion

The results of this study suggest that experts tend to quickly filter through the layers of a problem situation to determine the key elements, by drawing on their previous knowledge and personal experiences, as a first step in conceptualizing the ill-defined issues in a case-based problem. Regardless of whether individual, multiple, or composites of previous experiences were recalled, these were used to create personal rules which were not gleaned from knowledge or experience alone, but from a combination of the two. Specifically, knowledge and experience appeared to facilitate the problem solving process by providing the individual with:

1. A personal perspective or frame of reference, incorporating a mental model of the ID process, that guided the individual’s thinking about the problem and
2. A set of idiosyncratic rules of thumb that helped the individual reflect on specific ways to address the complex issues in the case.

According to Dufresne et al. (1992), “It is the organization and use of knowledge, not the knowledge itself, that play the pivotal role in successful problem solving” (p. 330). This suggests the need to rethink the way we scaffold student problem solving activities in order to more effectively enable them to organize their domain knowledge in ways that facilitate more expert problem solving. Based on the results of this study, we suggest three specific strategies for the education of designers: 1) helping students conceptualize the key issues in an ill-structured problem by scaffolding their analysis efforts to be more expert-like, 2) helping students accumulate a variety of ID experiences, either directly or vicariously, from which they can draw when faced with an unfamiliar design situation, and 3) enabling students to index these experiences in ways that facilitate efficient recall of relevant cases and/or principles when solving future ID problems. It is our hope that the use of these strategies will lead to more skillful problem-solvers who are able to strategically apply their knowledge, whether from textbooks or vicarious experiences, to articulate clear conceptualizations of ill-structured ID problems and, ultimately, to generate powerful and effective solutions.
References


