Design, Designers, and Reflection-in-Action

Monica W. Tracey and John Baaki

Keywords Design • Designers • Design thinking • Reflection-in-action • Designer self-reflection • Ill-structured problems • Design episodes • Design inquiry • Design exploration • Designer reflective conversation

Instructional designers are an integral part of successful design, and as a profession we are constantly looking to expand and improve our preparation methods in an effort to best prepare designers. Designers are active, influential change agents who work in a design space that includes interpersonal dimensions (Cross, 2011). They bring their own experience, perceptions, and interpretations of design to each project. Research on design in other disciplines indicates that aspects of the design process include research, reflection, conceptualization, and judgment (Nelson & Stolterman, 2003). Concepts including designer relation to design are superficially considered in some instructional design decision-making processes, but designers have yet to document their reflections during their design activities. Research on design seldom focuses on the designer while she is actually designing. Without deep understanding of what actually happens during design, we cannot prescribe improvements in design or preparing designers (Dorst, 2008). Reflection-in-action is one activity that may assist designers in improving their design activities.

M.W. Tracey (✉) • J. Baaki
Wayne State University, Detroit, MI 48202, USA
e-mail: monicatracey@wayne.edu

Design and Design Thinking

Depending on the context, design includes numerous definitions and descriptors. A summary of a study analyzing the most widely adopted textbooks and official definitions of the field of instructional design (Smith & Boling, 2009) indicated that design is a systematic process, represented by models, based on theory, and grounded in data while focused on problem solving (Tracey & Boling, 2013). When looking outside of the instructional design field, design is defined as "both a noun and a verb and can refer either to the end product or to the process" (Lawson, 2006, p. 3). In general, design is referred to as a generic activity (Lawson, 2006), a process, and a topic of study across disciplines that addresses complex human situations. Design is also defined as a space rather than a process, and design thinking is abductive (Cross, 2011; Dorst, 2011).

Design thinking incorporating abductive reasoning forces a designer to shift and transfer thoughts between the required purpose or function and the appropriate forms for an object to satisfy the purpose (Cross, 2011). In essence, designers move back and forth between an analysis space (required purpose or function) and a synthesis space (appropriate forms for an object to satisfy the purpose). The core challenge of design thinking is, in parallel, creating a complex object, service, or system and making it work (Dorst, 2011). Designers come up with the "what" and "how" and then test both in conjunction (Dorst, 2011, p. 5). Within a design space, designers need to tolerate uncertainty, interact with external representations (sketches, models, and other materials), rely on intuition, and take stock and reflect on the what and the how (Cross, 2011).

As instructional designers begin to look to the design worlds of architects, engineering designers, product designers, industrial designers, and software systems designers to truly understand what happens during design, instructional designers stand to gain much from reflective practice within design thinking. Cross (2011) indicates "there has been a significant history in design research of theoretical analysis and reflection upon the nature of design ability" (p. 5). Instructional designers can embrace best practices from reflection-in-action to assist them in developing their designer ability (Fig. 1).

Designers and Reflection-in-Action

As a specific type of reflective practice (how professionals think during practice), reflection-in-action emphasizes that unique and uncertain situations are understood through attempts to change them, and changed through the attempts to understand the situations (Schön, 1983). Reflection-in-action helps designers deal well with situations of uncertainty, instability, uniqueness, and conflicted values that are inherent in ill-structured problems (Schön, 1983).
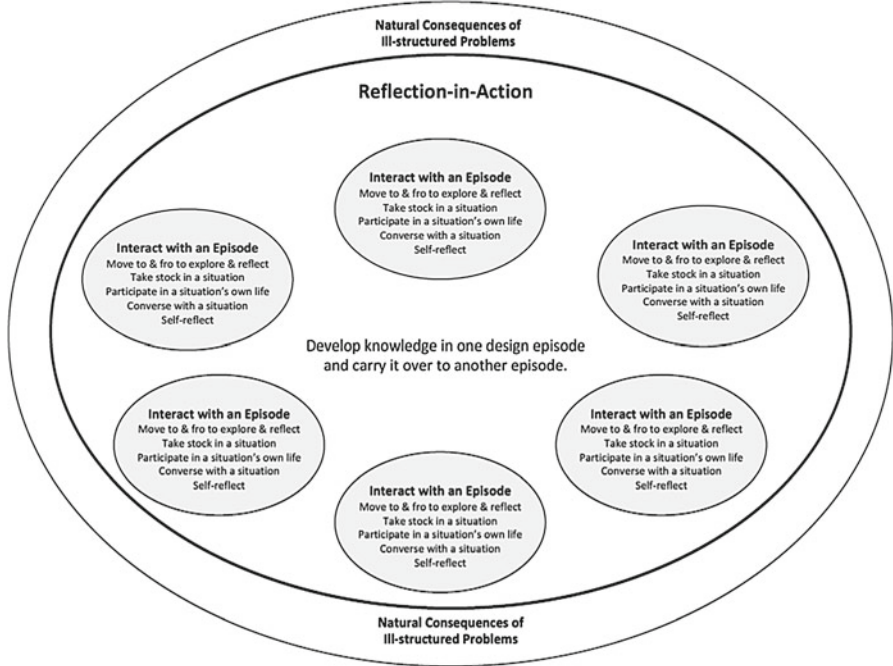
Fig. 1 A conceptual view of reflection-in-action

The second author headed a team that designed and developed an Internet Marketing web course for a major automaker's dealership sales consultants. The team's design ideas began to form when the team realized that customers who use the Internet should lead the 60-min web course. Using a whiteboard, the team sketched, interpreted, and developed three different Internet customers that would act as learning agents and present the course. Through biweekly, collaborative 60- to 90-min sessions that included quick interface sketching and storyboarding, the design team began to reflect on how the three Internet customer-learning agents would interact with learners through the web course interface. Through reflection-in-action, the team continued to design by digging into the Internet Marketing course secondary challenges: keeping ever-changing digital information current, choosing learning agents that are relevant across all dealerships, and developing current and useful Internet Marketing resources.

Working in a design thinking space (Cross, 2011), designers from different design fields, in the midst of the natural consequences of an ill-structured problem (Guindon, 1990), interact with a situation by having a reflective conversation with it. Designers are reflective participants in the design process (Scott, Shurville, Maclean, & Cong, 2007; Valkenburg & Dorst, 1998). To understand designers inter-acting with design episodes and having a reflective conversation with the situation, design thinking literature points to reflective practice ideas (Adams, Turns, &

Atman, 2003; Atman, Cardella, Turns, & Adams, 2005; Atman, Chimka, Bursic, & Nachtmann, 1999; Ball, Onarheim, & Christensen, 2010; Goel & Grafman, 2000; Guindon, 1990; Scott et al., 2007; Valkenburg & Dorst, 1998), especially to reflection-in-action (Schön, 1983, 1988). The idea of reflection-in-action is that unique and uncertain situations are understood through attempts to change them, and changed through the attempt to understand them (Schön, 1983, 1988).

Several researchers have indicated that reflection-in-action is best appreciated within the context of design activity. A design process has four aspects of design activity: (1) designer, (2) process, (3) content, and (4) context. Of the four aspects, designer is the most straightforward. Process is looking at design in two different ways: (1) rational problem solving and (2) reflective practice (Brown, 2008; Cross, 2011; Dorst, 2008; Schön, 1983). Content involves complex and uncertain design problems and the emerging solutions (Dorst, 2008; Schön, 1983). In general, a designer works in a particular context. A specific aspect of context is how designers draw from a repertoire of precedents inside and outside of the project (Brown, 2008; Cross, 2011; Dorst, 2008; Guindon, 1990; Schön, 1983). Studying and sharing design precedent has been gaining traction in the field of instructional design through journals, such as *The International Journal of Designs for Learning,* where designers share their designs plus detailed descriptions of their decision-making activities during design.

Theoretical Foundations of Reflection-in-Action

Theoretical foundations of reflection-in action include Donald Schön's (1983) theory of reflective practice and Kolb's (1984) work on experiential learning theory. Schön's (1983) theory of reflective practice or how professionals think in practice was developed to counter the rationality or scientific theory and techniques applied to practical problems (Cross, 2011). Schön attempted to explain how practitioners actually engage with their practice and discovered that designing appears to include a reflective conversation during and with the situation. When a designer is presented with a complex problem or situation, the designer shows a series of questioning, making a decision, reflecting on the consequences of the decision, then making another move. Main concepts are the notions of reflection-in-action, which refers to allowing one to experience the feelings and emotions inherent in a situation, and reflection-on-action, which refers to reflecting on something after it has happened through various methods, such as recording one's thoughts or talking about an event after it has taken place (Schön, 1983). This chapter focuses specifically on reflection-in-action, the reflection that occurs during design.

Kolb's (1984) experiential learning theory, although based on the experiences learners have, has value when looking at designers during designing. Kolb described experiential learning, grounded in experience, as a four-stage cycle based on the experiences learners encounter. The designer therefore observes and reflects on the design during the design experience. The designer then forms concepts, and perhaps rules, based on how the experience has been understood by observation and the reflection process. Finally, the designer tries out this new understanding in the next

design situation. Experiential learning theory states that these four stages occur as part of the natural learning process. Designers as learners in every design experience engage in these four stages and, if observation and reflection are allowed and encouraged, can bring new insight to the next design experience, either working alone or with a team of other designers. Each designer brings his or her experiences to every new design experience.

Perspectives of Reflection-in-Design

Reflection-in-design can occur when designers deal with the natural consequences of ill-structured problems (Jonassen, 1997). Designers also interact with design episodes, including the movement between exploration and reflection, taking stock of a design situation, and participating in an episode that takes on a life of its own (Cross, 2011), each embracing reflection-in-action. Designers also have reflective conversations with the design situation and participate in a self-reflection process. One perspective of reflection is looking at the natural consequences of ill-structured problems.

Natural Consequences of Ill-Structured Problems

In the complex world of design, Guindon (1990) uses an interesting phrase to describe deviations in the design process. He notes from his study of software systems designers, "The analyses show that these deviations are not special cases due to bad design or performance breakdowns but are, rather, a natural consequence of the ill-structuredness of problems in the early stage of design" (p. 307). Ill-structured problems make design problems particularly difficult because ill-structured problems are incomplete and have ambiguous goals, have no predetermined solution path, and require an integration of multiple knowledge domains (Guindon, 1990).

As software systems designers reflected on an ill-structured problem involving the lift systems control of an elevator, Guindon (1990) observed systems designers drawing on multiple knowledge domains like design, software systems architecture, and computer science and found the designers weighing pros and cons of alternative solutions. As solutions began to evolve, designers reflected on the internal consistency, correctness, and completeness of a solution with respect to requirements, whether given, inferred, or added. An interesting consequence of the ill-structuredness of the problem was that when reflecting on an external representation of the solution, the software systems designers would change goals and immediately fix a newly discovered bug (Guindon, 1990). This closely ties to the idea of interacting with episodes (discussed later) by taking stock of the situation and making improvements.

It is this fixing the bugs now as a consequence of the ill-structured problem that provides a relevant introduction of Schön's (1983) reflection-in-action process. Reflection-in-action helps designers deal well with situations of uncertainty, instability, uniqueness, and conflicted values, which are inherent in ill-structured

problems (Schön, 1983). Because design is complex and full of ill-structured problems, designers treat design cases as unique since they cannot deal with situations of uncertainty by applying standard theories and techniques.

Schön (1983) emphasizes reflection-in-action, rather than reflection-on-action. For Schön (1983), unique and uncertain situations are understood through attempts to change them, and changed through the attempt to understand them. In order to change the situation and understand the situation, designers reframe a situation by asking five questions: (1) Can I solve the problem I have set? (2) Do I know what I get when I solve the problem? (3) Have I made the situation coherent? (4) Have I made it congruent with my fundamental values and theories? and (5) Have I kept inquiry moving? (Schön, 1983).

Schön (1983) contends that much of reflection-in-action centers on the experience of surprise. Adams et al. (2003) connect reflection-in-action to this notion of surprise. For the Internet Marketing web course design team, surprises stemmed from the unpredictability of complex design situations like how to ensure sales consultants use critical thinking skills as they apply to best practices, how to present nonlinear content in a SCORM-compliant course, and how to quickly provide context around each learning agent through a combination of animation and narration. In these situations, Schön (1983) brings to light that the situation talks back and this back talk helps designers engage in a reflective conversation with the materials. Adams et al. (2003) conclude that this reflective conversation can help designers develop deeper understanding of the design problem.

What is important to take from the natural consequences of ill-structured problems is that designers design under conditions of complexity and uncertainty (Schön, 1988) and that designers analyze why actions do not lead to expected consequences and then form new plans for action and trying out new steps (Holmquist, 2007). Before any script, motion sample, and interface design were shared with the automaker, the Internet Marketing web course design team reflected quickly on four rounds of interface design sketches, two rounds of motion samples, and one script version 1.0. Each round triggered a new round of designing where a different sort of designing began. In the Internet Marketing web course design and development, an interesting outcome from the natural consequences of ill-structured problems is that the design team began to break down the overall design assignments into smaller situations or moves. The team would break down an 8-min module into the specific 20–30-s scenes than make up the module. Through reflection, designers can "rationally" make a decision to start a new activity (Valkenburg & Dorst, 1998). Using "rationally" is interesting as designers begin to make sense of ill-structuredness. Reflection within a situation of uncertainty and complexity leads designers to interact with an episode and participate in a reflective conversation with the situation.

Interaction with Episodes

The design process is episodic, which has strong implications for reflection from three perspectives: (1) Designers move to and fro between exploration and reflection,

(2) Designers take stock of a design situation, and (3) Designers participate in an episode that takes a life of its own (Cross, 2011). The Internet Marketing web course team often interacted with episodes by drawing on its knowledge of learning routines used in a previous course or a favorite practice item that emphasizes critical thinking skills. For example, the subject matter expert wanted to ensure that sales consultants understand what makes up a good follow-up email to a customer. Drawing on a drag-and-drop learning routine, the design team emphasized critical thinking skills by designing a practice item where sales consultants actually composed a follow-up email. The scriptwriter, the graphic designer, and instructional designer engrossed themselves in frame experiments as they moved to and fro between exploration and reflection. Taking stock of the design situation, the design reflected on many ideas to clarify vague ideas and move forward to a follow-up email practice routine.

Designers treat each design episode as unique (Schön, 1988). Designers build up knowledge in a cumulative and contemplative way, develop knowledge in one design episode, and carry it over to the next episode. Episodes can be complex and have lives of their own which may foil a project and create new meaning (Schön, 1983). As an external representation, design is constructed in public so other people can read and comment on it (Cross, 2011). Designers draw and sketch as a means of thinking out loud and as a process of criticism and discovery.

Move To and Fro Between Exploration and Reflection

Schön (1983) makes it clear that when reflecting in action a designer can think about doing and can think about doing something while doing it. In the midst of performance, reflection-in-action is bounded by an "action-present" zone of time (from minutes to months) in which action can still make a difference to the situation. For example, in looking at architects designing a lab configuration, Goel and Grafman (2000) conclude that designers generate a single idea or fragment and develop it through transformations where it is complete and can be evaluated. Even though these episodes were sometimes short, averaging between 1.2 and 1.6 min, actions like lab circulation patterns and placement of printers and workstations made a difference in the final design. The movement back and forth between exploration and reflection keeps the project moving forward as design transformations continue.

Take Stock of a Design Situation

Schön (1983) would argue that *action-present* is really actually taking stock of the design situation. Here, a designer takes account of unintended changes by framing new appreciations and understandings by making new design moves. Why take stock of the design situation? From multiple studies of engineering design students participating in design activities, Adams et al. (2003) conclude that reflection-in-action provides a means to fill gaps. The authors surmise that reflection-in-action

allows designers to see new design requirements emerge and subsequently design-ers synthesize these new requirements into solution development. What is important in the process is that designers do not identify the requirements until they have designed and reflected on portions of the system.

In designing a web course, it is essential to ensure that learners find consistency in how they interact with the course. When reflecting on script version 1.0 and the initial motion sample, the Internet Marketing web course design team realized that the initial course designs did not consistently identify differences between content, examples, practice items, and feedback. New design requirements emerged from these designed portions of the web course. The design team decided that content would use the entire user interface, while sales consultants would trigger examples and practice items by interacting with a cell phone or computer screen interface. Through reflection-in-action, the design team participated in an in-depth exploration of solution ideas. The design team assessed the viability of uncertain ideas like no distinction between course content and examples and practice items and then gained confidence in the idea of presenting different interfaces for content and practice.

Participate in an Episode That Takes a Life of Its Own

In his study of architects, Schön (1988) asserts that skilled designers tend to treat each design situation or episode as unique. From this, designers build up knowledge in a cumulative way, develop knowledge in one design episode, and carry it over to the next episode. Although a designer may see each episode as unique, a good designer sees an episode as something that is part of a designer's repertoire (Schön, 1983). In other words, a designer sees a current episode as an episode from before so that a designer may pull from the earlier episode and use something in the new episode. Even though a designer contributes to an episode, episodes can be complex and have lives of their own, which may foil projects and create new meanings (Schön, 1983). Interacting with an episode means participating in a reflective con-versation with the situation.

Reflective Conversation with the Situation

Because ill-structured problems are dynamic and complex, Schön (1983) explains that in good design processes designers engage in a reflective conversation with the design situation, answer the situation's back talk, and reflect-in-action on the con-struction of the problem, strategies of action, or models of the phenomena. When absorbed in a reflective conversation with a design situation, reflection-in-action has three critical dimensions: (1) a designer's language as she describes and appreciates the particular consequences of design moves, (2) the implications that are discov-ered and followed, and (3) the changing stance toward a design situation (Schön, 1983). In a situation's back talk, a designer can discover a whole new idea, which

generates a system of implications for more moves. In other words, answering a situation's back talk results in a shift in a designer's stance. Keeping in mind that the design situation is engulfed in complexity and uncertainty, a designer shifts from "What if?" to do something with the episode, and a designer's stance shifts from exploration to commitment (Schön, 1983).

Adams et al. (2003) concur with Schön that reflection is critical to practice. A designer reflectively converses with a situation by framing the problem, naming things a designer attends to do within the frame, generating moves toward a solution, and reflecting on outcomes of the moves (Adams et al., 2003). The result is coupled iterations (Adams et al., 2003) where a designer revises problem understanding in the context of developing or revising solution elements. This is what Schön (1983) describes as a designer engaging in a conversation across problem and solution spaces where solution spaces are not yet fully developed.

In a study that really brings to light reflective conversation with a design situation, Valkenburg and Dorst (1998) examined engineering teams who competed in designing and building remote-controlled robots that had to transport as many balls as possible from a ball bin into a basket. Using episodes as raw data instead of traditional protocol analysis time intervals, Valkenburg and Dorst (1998) visualized four activities—naming, moving, reflection, and resetting the frame—in 30 min of the protocol. The first activity of the design team was naming relevant objects within the design situation: shooting the ball, collecting the balls, and driving the robot. In the second activity, the design team chose the most important relevant object to handle first. During reflection-in-action, the competing team asked and discussed: (a) What do we do now? (b) What do we have now? (c) Is this all? and (d) Does the robot have to shoot? The result was resetting the frame into getting balls into a basket as the most important problem issue.

What is significant is that in this design competition the team that spent the most time on reflection won. For the winning team, reflection occurred early and often. The winning team's reflected moments always occurred in relation to the design task. For the losing team, reflection happened at the end where it was too late to intervene with the project. The losing team's reflected moment was the team's last activity. In this design competition, early and multiple reflective conversations with the design situations affected which design team won the competition.

Designer Self-Reflection

Reflection should occur individually as well as within a design team during design. Self-reflection is the process of looking at one's self to understand feelings and emotions. Self-management may follow the process as a way to manage those feelings and emotions (Bradberry & Greaves, 2005). Based on their research, Hixon and Swann (1993) suggest that self-reflection, a meta-emotional activity, is essential to self-knowledge. It is through self-knowledge that designers are able to self-evaluate (a metacognitive function) and move deeper into expert status. Studying medical physicians and the need for and measurement of self-reflection, Aukes,

Geertsma, Cohen-Schotanus, Zwierstra, and Slaets (2007) discovered that self-reflection is considered a *mental hygiene* component to a physician and creates the ability to develop professionally, particularly in solving problems (Aukes et al., 2007). Educational theories focus on reflection as part of the process of active learning and learning through inquiry. Reflection is considered "metacognition" because it refers "to a response that considers the action itself and its relationship to the knowledge structure, that generated it, as well as the extent to which it achieved the intended goal" (Laurillard, 2012, p. 76). Designer self-reflection can provide the opportunity for a designer to look at design actions, the learning that resulted from those actions, and how the actions helped or hindered the ultimate goal along with building the designers' repertoire in design.

Throughout the Internet Marketing web course design, the instructional designer and lead project manager met periodically to discuss what was going well with the reflection-in-action approach, what was not going well, and what needed to change. This was particularly helpful when the design team faced design obstacles like the subject matter expert's desire to change the module sequence and when milestones had to be adjusted because the subject matter expert and the automaker team missed feedback deadlines.

In other fields—for example, psychotherapy—it is common knowledge that therapists can alter therapy outcomes through their behavior and reactions; therefore, supervisory sessions where self-awareness occurs and is articulated are considered critical to therapist development (Moffett, 2009). Novice therapists are asked to reflect upon their thoughts and feelings before, throughout, and/or after patient sessions (Fauth & Williams, 2005). Methods of implementation vary but often include structured questions that ask how the therapists *would* think/feel, what they *are* thinking/feeling, or what they *previously* thought/felt during client sessions. The process of self-awareness comprises both self-reflection and self-management. Self-awareness for the purpose of this discussion is the extent to which one can identify how one is feeling and how these feelings may be affecting, for example, client interactions, design decision-making, and design team interfaces. Self-management is the level at which an individual can direct actions and perceptions in such a way that more effective outcomes are possible.

After the subject matter expert's and automaker team's first review of script version 1.0, the interface look and feel, and the initial motion sample, some design team members felt frustrated and disappointed with the amount of feedback received. Should the design team have fleshed out more design details before presenting such early design "sketches"? After some self-reflection, the design team concluded that in the reflection-in-action spirit, it was important for the subject matter expert and automaker team to take stock in and react to the early design episodes. This early feedback was essential to designing script versions 2.0 and 3.0 and the experience design document that visually presented all learning routines.

Self-reflection provides an opportunity for designers to measure their thoughts, understandings, and actions. Concepts including designer self-awareness, introspection, self-insight, and interpersonal choices are superficially considered in some design decision-making processes, but an in-depth look at these activities is often neglected in studying instructional designers during the process of design. This may

in part because of the nature of instructional design models embodying the design process, not the designer as a part of that process.

Implications on Design and Designers

Design involves dealing with uncertainties and designers must not only learn to deal with uncertainty but embrace and use uncertainty as a tool to propel optimal design solutions. Design is a complex activity most often involving ill-structured problems (Jonassen, 1997). Instructional designers should be prepared to deal with ill-structured problems and the complexity design inherently brings. It is time to prepare instructional designers in a similar fashion to other design professions. Cennamo et al. (2011) state that "the education of engineers, instructional designers, architects, landscape designers, and the like must, by necessity, prepare students to solve the very complex and ill-structured design problems with which they must grapple as professionals" (p. 13). Design thinking (Cross, 2007; Lawson & Dorst, 2009) and reflective designing (Lowgren & Stolterman, 2004) explain how no single approach to designing can address every future situation effectively, so the designer must be prepared to appreciate design situations subtly and with discipline, invent and reinvent processes, and take personal responsibility for the effects of their designs rather than handing off responsibility for quality outcomes to a single process or theory (Nelson & Stolterman, 2003).

Instructional designers bring different backgrounds and abilities to the classroom, studio, and/or workplace along with very different understandings of what design is and their role in it. Those who view design as a tradition distinct from science and who study how it occurs in practice present design not as a smooth systematic process. In addition, designer's values, belief structures, prior experiences, knowledge and skills, and their approach to design affect the final outcome (Nelson & Stolterman, 2003). Lawson and Dorst (2009) present a three-dimensional model of the constraints on designs, a view not intended to represent all facets of designing but one which "casts the designer not as a traveler along a winding process path, but as an actor in a space shaped both externally by constraints and internally by the designer himself" (p. 131). In this view, designers have to appreciate and impose constraints, and they have to manipulate the conceptual space in which they are working in response to those constraints (Tracey & Boling, 2013). Reflection-in-action during design can assist the instructional designer to acknowledge the uncertainty, identify the ill-structuredness of the design problems, and embrace the complexity inherent in the design solution.

Conclusions

Reflection-in-action is just one element of a design thinking approach to instructional design. Within a design thinking approach, instructional designers can learn much from how reflection-in-action can help solve design problems, align a

designer's fundamental values with the design solution, ensure design situations are coherent, and, maybe most importantly, keep inquiry moving. Cross (2011) suggests that a considered and reflective approach to design and consideration of alternative solution concepts might save time and effort in the long run. Schön (1983) agrees as he discusses that reflection early on with pencil and paper, and well before a build, is a lot cheaper. Design moves that are costly during a build can be "…tried at little or no risk in the world of drawing" (Schön, 1983, p. 158).

Schön (1983) considers how reflection-in-action in a unique case may be generalized to other design cases. This occurs not by forming general principles, but adding to a designer's repertoire of important themes from which a designer can pull in future design projects. But, how can instructional designers become efficient and effective in reflection-in-action? Instructional designers can learn from design disciplines as design students are exposed to complex design problems. For example, Atman et al. (2005) note that as part of homework engineering design students are given complex design problems with varying task environments.

Dorst (2008) believes that designers can only foster a deeper understanding of design activity when all aspects of design activity are considered. Although there is research regarding the process of design activity, what research lacks are the other three aspects of design activity: (1) designer, (2) context, and (3) content (Dorst, 2008). Dorst (2008) advocates a new type of design research, "…in which the process and content of design activity are connected with a model of designer and the context in which designing is taking place" (p. 7). In regard to a reflection-in-action approach to improving a design while it is fluid, interesting research opportunities could include how individual designers reflectively converse with design situations as compared to how design teams converse; how levels of designers—novice, advanced beginner, competent, real expert, master, and visionary (Dorst, 2008)—reflect differently from one another; how context affects reflective practice; and how the design project's content affects reflection.

A reflective conversation with a design situation can be an effective way to judge the strengths and weaknesses of a design project while it is fluid. This has critical implications for most design projects, as they are complex, uncertain, and ill structured. A reflection-in-action approach is designed to operate in a complex world. It is this complex world where instructional designers engage in actual design practice.

References

Adams, R. S., Turns, J., & Atman, C. J. (2003). Educating effective engineering designers: the role of reflective practice. *Design Studies, 24*, 275–294. doi:10.1016/S0142 694X(02)00059-X.

Atman, C. J., Cardella, M. E., Turns, J., & Adams, R. (2005). Comparing freshman and senior engineering design processes: An in-depth follow-up study. *Design Studies, 26*, 325–357. doi:10.1016/j.destud.2004.09.005.

Atman, C. J., Chimka, J. R., Bursic, K. M., & Nachtmann, H. L. (1999). A comparison of freshman and senior engineering design processes. *Design Studies, 20*, 131–152.

Aukes, L. J., Geertsma, J., Cohen-Schotanus, J., Zwierstra, R. P., & Slaets, P. J. (2007). The development of a scale to measure personal reflection in medical practice and education. *Medical Teacher, 29*(2–3), 177–182. doi:10.1080/01421590701299272.

Ball, L. J., Onarheim, B., & Christensen, B. T. (2010). Design requirements, epistemic uncertainty, and solution development strategies in software design. *Design Studies, 31*, 567–589. doi:10.1016/j.destud.2010.09.003.

Bradberry, T., & Greaves, J. (2005). *The emotional intelligence quick book: Everything you need to know to put your EQ to work*. New York: Fireside.

Brown, T. (2008). *Change by design*. New York: Harper Business.

Cennamo, K., Brandt, C., Scott, B., Douglas, S., McGrath, M., Reimer, Y., et al. (2011). Managing the complexity of design problems through studio-based learning. *The Interdisciplinary Journal of Problem-Based Learning, 5*(2), 12–36.

Cross, N. (2007). *Designerly ways of knowing*. London: Springer.

Cross, N. (2011). *Design thinking: Understanding how designers think and work*. London: Berg.

Dorst, K. (2008). Design research: A revolution-waiting-to-happen. *Design Studies, 29*, 4–11. doi:10.1016/j.destud.2007.12.001.

Dorst, K. (2011). The core of "design thinking" and its application. *Design Studies*. doi:10.1016/j.destud.2011.07.006.

Fauth, J., & Williams, E. N. (2005). The in-session self-awareness of therapist trainees: Hindering or helpful? *Journal of Counseling Psychology, 52*(3), 443–447. doi:10.1037/0022-0167.52.3.443.

Goel, V., & Grafman, J. (2000). Role of the right prefrontal cortex in ill-structured planning. *Cognitive Neuropsychology, 17*(5), 415–436. doi:10.1080/026432900410775.

Guindon, R. (1990). Designing the design process: Exploiting opportunistic thoughts. *Human Computer Interaction, 5*, 305–344.

Hixon, J. G., & Swann, W. B., Jr. (1993). When does introspection bear fruit? Self reflection, self-insight, and interpersonal choices. *Journal of Personality and Social Psychology, 64*, 35–43.

Holmquist, M. (2007). Managing project transformation in a complex context. *Creativity and Innovation Management, 16*(1), 46–51. doi:10.1111/j.1467 8691.2007.00416.x.

Jonassen, D. (1997). Instructional design model for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology Research and Development, 45*(1), 65–95.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology*. New York: Routledge.

Lawson, B. (2006). *How designers think: The design process demystified* (4th ed.). Oxford, UK: Elsevier.

Lawson, B., & Dorst, K. (2009). *Design expertise*. Oxford, UK: Elsevier.

Lowgren, J., & Stolterman, E. (2004). *Thoughtful interaction design: A design perspective on information technology*. Boston, MA: MIT Press.

Moffett, L. A. (2009). Directed self-reflection protocols in supervision. *Training and Education in Professional Psychology, 3*, 78–83.

Nelson, H. G., & Stolterman, E. (2003). *The design way: Intentional change in an unpredictable world: Foundations and fundamentals of design competence*. Englewood Cliffs, NJ: Educational Technology Publications.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Boston: Basic Books.

Schön, D. A. (1988). Designing: Rules, types, and worlds. *Design Studies, 9*(3), 181–190.

Scott, B., Shurville, S., Maclean, P., & Cong, C. (2007). Cybernetic principles for learning design. *Kybernetes, 26*(9/10), 1497–1514. doi:10.1108/0368 4920710827445.

Smith, K. M., & Boling, E. (2009). What do we make of design? Design as a concept in educational technology. *Educational Technology, 49*(4), 3–17.

Tracey, M. W., & Boling, E. (2013). Preparing instructional designers and educational technologists: Traditional and emerging perspectives. In M. Spector, D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology*.

Valkenburg, R., & Dorst, K. (1998). The reflective practice of design teams. *Design Studies, 19*, 249–271.