Designing and Instructional Design

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What do we know about the process of designing instruction? We have a large body of literature and numerous prescriptive models, yet it is not clear that designers actually operate as the literature and models suggest. Other design fields, such as architecture and engineering, have similar concerns, but have acted upon those concerns by systematically investigating design processes. Considering the results of such studies may prove beneficial to instructional designers in terms of promoting critical analysis of processes and decisions and identifying questions and hypotheses for research. In this article, results from numerous studies of design are synthesized to provide a basis for considering instructional design as a type of designing rather than an isolated phenomenon.

☐ Instructional design (ID) is frequently traced to roots in areas such as systems theory and communications (e.g., Reiser, 1987), and representations of the process frequently reflect those roots. But just how accurate are such representations when compared with what designers actually do in practice? We do not really know. The body of literature describing and prescribing ID processes is based primarily on experts' opinions and recollections rather than on systematic investigation. This literature, on the whole, shares a view of ID as a deterministic, essentially rational and logical process, a set of procedures to be followed. Lack of success, either with the process or the product, is blamed on poor implementation by the designer(s) or on the primitive state of an emergent science of instructional design.

An alternative explanation is that the view itself is inadequate. ID may be better characterized as a creative process, based on intuition as well as rationality, involving divergent as well as convergent processes (e.g., Banathy, 1987; Earl, 1987), or as a dialogue rather than a process of optimization (Tripp, 1991). Again, we do not know, because we have relied on what the experts say they do, or say what others should do, and perhaps have missed what instructional designers themselves actually do.

Concern that descriptions of instructional design in the literature are discrepant with practice is growing (e.g., Gayeski, 1991; Lewis

& Bjorkquist, 1992; Pirolli & Greeno, 1988) and appears to mirror similar situations experienced in other design fields over the past 20 years. The theoretical bases of such fields as architectural and engineering design have been challenged on the grounds that they fail to account for the complexities and constraints of practice (see, for example, Jones, 1970). Studies of designers engaged in the act of designing have been carried out (e.g., Akin, 1978; Cross, 1982; Eastman, 1972; Foz, 1973; Schon, 1983; Ullman, Stauffer, & Dietterich, 1987), and, as a consequence, new descriptions and models of the design process are emerging.

Instructional design is likely to profit from similar studies. The few studies that have been carried out to date have proved valuable and have found (1) clear similarities between ID and other fields of design, and (2) areas in which ID practice differs substantially from the common view of how instruction is or should be designed (Kerr, 1983; Nelson, 1988; Rowland, 1992). This article addresses the former concern and examines the more general characteristics of design that are likely to hold for all types of designing, including ID. A general definition of design is offered, then elaborated in a series of descriptive statements. The purpose is to consider what systematic examination of different types of designing has revealed. To the extent that ID is a subset of design, this may offer a new and fresh perspective on ID, and perhaps the means to get past an outdated view.

A DEFINITION OF DESIGN

Design is a disciplined inquiry engaged in for the purpose of creating some new thing of practical utility. It involves exploring an ill-defined situation, finding—as well as solving—a problem(s), and specifying ways to effect change. Design is carried out in numerous fields and will vary depending on the designer and on the type of thing that is designed. Designing requires a balance of reason and intuition, an impetus to act, and an ability to reflect on actions taken.

This general definition attempts to capture many attributes of design cited in a variety of literature. Individual attributes are stated and described below in four loose categories:

1. the purpose or goal of designing
2. relationships to other processes
3. factors that influence the design process
4. the nature of the design process.

THE PURPOSE OF DESIGNING

Design is a goal-directed process in which the goal is to conceive and realize some new thing (Cross, 1982). Design has changed as society and technology have changed. For example, Jones (1970) describes a series of shifts in how design is carried out. Design as a craft gave way to design-by-drawing as the scope of products became larger and more complex. A third method for designing, systems engineering, became prevalent when the individual was no longer able to manage all components of the process. Across these three methods, the means and ends of designing and the attributes of design problems may have changed, but the purpose has remained constant. Design is engaged in for the purpose of changing an existing situation into a preferred one (Simon, 1981). Whether that change—that is, the goal of designing—involves a new computer system or an illustration, an automobile or a building, a change in the skill of an individual or a plan of action, the designer focuses his or her efforts toward achieving a particular end for the case at hand. Designing, therefore, is a type of planning and results in an organized plan for achieving a special purpose.

> To design is to plan and organize, to order and relate and to control. In short, it embraces all means that oppose disorder and accident. (Josef Albers, in Lauer, 1985, p. 239)

The new thing that results from designing has practical utility (Holt, Radcliffe, & Schoorl, 1985). There may be similarities between designing and other processes, such as painting or composing music, but designing results in something new or a new combination of elements that serves a practical purpose. The result of designing might be a poster to inform people of an upcoming event, a machine component to perform a specific function, an instructional lesson to teach something, an environment in which certain activities can be carried out, or a tool for carrying out a particular set of tasks. In each case, the end result of the design process is a devised product or artifact that is intended to have practical utility.

THE RELATIONSHIP OF DESIGN TO OTHER PROCESSES

Design is similar to some types of composing. Composing, either prose or music, is frequently intended for a particular situation, setting, audience, and medium. For example, a composer of music may be called upon to create an accompaniment for a scene in a motion picture. He or she is constrained by the theater setting, the intended audience, and the method of reproduction, and is required to support the writer's and director's goals for the scene. This may be quite different from the activity of composing a concert piece with few externally imposed constraints. Once again, the key is that the new creation is intended to satisfy a specific practical purpose.

Design may be a science, or a combination of science and art, or neither science nor art. Some argue that a science of design is possible and represents an important goal. For example, Hubka and Eder (1987) call for "determining and categorizing all regular phenomena of the systems to be designed, and of the design process" (p. 124). The assumption is that there are, in fact, regular phenomena that can be codified and predicted, and that prescriptions can thus be made.

Cross (1982), reporting on a number of studies of design, argues that design is quite different from science. While scientists focus on the problem, on discovering the rule that is operating, designers focus on the solution, on achieving the desired result (Lawson, 1980). The scientific method is employed to discover the nature of what exists, while design methods are employed to invent things which do not exist (Gregory, 1966). Science is essentially analytic, and design is constructive (Gregory, 1966). And while the designer is constrained to produce a practical product within a specific time limit, scientists choose to suspend judgment and decisions (Cross, 1982).

The need for artistry in designing is noted by numerous authors (e.g., Allen, 1988; Holt et al., 1985; Hubbell, in Marshall & Kifer, 1989). Frequently, design is characterized as a combination of artistry and technical skill. For example, Jones (1970) comments that successful designers are able to combine reason with imagination and to be simultaneously creative and practical.

Others agree that a mix of rational and creative processes are found in design (and, for that matter, in science and in art), but argue that design is a separate area of knowledge, neither science nor art. Cross (1982) provides a number of distinctions between science, humanities, and design. These are summarized in Table 1. For the purpose of this discussion, the "humanities" column may be taken to represent art (as in "arts and humanities"). One could argue against some of these distinctions,

TABLE 1 □ Distinctions between Science, Humanities, and Design

	Science	*Humanities*	*Design*
Phenomenon of study	Natural world	Human experience	Man-made world
Appropriate methods of Study	Controlled experiment Classification Analysis	Analogy, metaphor Criticism Evaluation	Modeling Pattern formation Synthesis
Values	Objectivity Rationality Neutrality Concern for "truth"	Subjectivity Imagination Commitment Concern for "justice"	Practicality Ingenuity Empathy Concern for "appropriateness"

Note: This table was constructed from distinctions made by Cross (1982).

but the overall point is a reasonable one: design is a particular discipline with its own areas of interest, methods, and values.

FACTORS THAT INFLUENCE THE DESIGN PROCESS

The design process is dependent on the designer and on what he or she designs. The design process will be affected by many factors, among them the designer's knowledge, skill, and experience; the design task; the working conditions and environment; and methods and management. Hubka and Eder (1987) describe how these and other factors affect such things as the quality of the design, the duration and efficiency of the design process, and the cost of designing. Of particular importance are the object(s) being designed and the perspective of the designer, i.e., does he or she view the problem as one which requires designing? With regard to the latter, neither the problem nor the solution determine that designing must occur; more important is how the individual perceives the situation and his or her role with respect to it (Thomas & Carroll, 1979). This perspective is primary in determining how problem solving will occur.

In terms of the design objects, Hubka and Eder (1987) found that the design process was substantially influenced by what it was that the individual designed. For example, the process to design an electric motor could be expected to be different from that used to design a poster or a building. This appears at first to contradict Thomas and Carroll's (1979) contention that the designer's perspective is of primary importance. However, Thomas and Carroll's argument focuses on the purpose of the object, not necessarily the type of object. For example, the perceptions that the object must perform a practical task and that no object currently exists to satisfy that purpose may trigger designing, while the way the designing proceeds may differ depending on whether the object is a computer system, a building, or a plan of action. In particular, variations in designing may depend on the goals and criteria set by the designer in response to the object's purpose. For example, a manufacturing plant and an art museum are both buildings, but the goals and criteria designers set in response to the different purposes of these buildings would likely influence how the design process proceeds.

Design requires social interaction. Design could be carried out more or less in isolation and provide a particular product for one individual's use. More typically, the designer is a member of a team and the product is intended to serve many and to be marketed for profit. The social utility of the product is a concern, and designing necessarily involves social interaction. For example, the needs, desires, values, and preferences of potential customers and how much they can afford to pay for the product must be assessed. The perceptions of team members (e.g., other designers, producers, managers, and marketing agents) will also affect the process. As a consequence, designing involves managing human factors such as communication, power, and anxiety, as well as any conflicts of interest that arise (Holt et al., 1985).

The designer will frequently work with a client. As Thomas and Carroll (1979) point out, the designer and the client will bring different expertise to the problem. The client brings knowledge of goals and details of the situation. The designer brings knowledge of relationships between goals and potential solutions. The two "exchange enough knowledge to produce a solution that is feasible (can exist) and is likely to help the client achieve the goals" (p. 6). Clearly, the client, the designer, and their interactions will affect how the design process occurs.

THE NATURE OF THE DESIGN PROCESS

Designing involves problem solving, but all problem solving is not designing. Problems are situations in which people do not have the means to cross the gap between where they are and where they want to be. In order to cross the gap, they must understand the nature of the problem and find ways to solve it (Hayes, 1987). The creation of some new product will always involve assessing and crossing this gap, i.e., understanding and solving a problem.

There are problems, however, that do not require designing. The distinction is in the nature of the problem and in the relationship between the problem and the solution. Design problems are ill-defined (e.g., Reitman, 1965; Suchman, 1987; Thomas & Carroll, 1979). In general, the problem and the means to solve it are unclear and must be found by the designer. And when designing is finished, there is still some uncertainty as to the adequacy of the solution. To illustrate this, here are two problems:

1. An architect is asked to design a new building. She has an idea of how to proceed but cannot be certain that this will lead to an effective design. She seeks to gain a rich understanding of how the building is to be used, who will use it, what the owners' priorities are, and so on. She attempts to create a design that satisfies these requirements, but she is never entirely sure that all requirements were identified, which variations in design components best accommodate the constraints of the situation, or how stable requirements will be over time. The process and criteria were not clear at the beginning, and the adequacy of her solution is not entirely clear at the end.

2. A mathematics student is presented with a problem. He searches the problem statement for the variables that are involved, and for which values are given and which must be found. That is, he tries to understand what the problem is. He identifies the problem as being a certain type and obtains an appropriate formula(s), either from memory or from some external source. He applies the formula(s) and derives the solution. The instructor reviews the student's solution and marks it correct, i.e., a single correct solution is known to the instructor. It is likely also that the instructor knows some limited number of appropriate and efficient paths to that solution and can assess the student's problem-solving process.

Both examples involve problem solving, but only the first can be called designing. The mathematics problem is well-defined. It has a single correct solution that the instructor or anyone else with the appropriate knowledge can obtain, given the problem statement. The initial conditions, and appropriate and efficient paths to the solution can be identified up front. This is not the case with the building problem. A nearly infinite number of different solutions to this same problem are possible, and one can never say with certainty which solution is best. One can only hope for a satisfactory solution that meets most or all of the requirements. Neither the initial conditions nor the most appropriate and efficient process to obtain a satisfactory solution are entirely clear. Also, the complexity of the problem is not the key distinction. A mathematics problem can be very complex, but the initial conditions of the problem, a single solution, and a limited number of paths to that solution are generally agreed upon.

Because design problems are ill-defined, all information is never available to the designer; design problems are not susceptible to exhaustive analysis (Cross, 1982). This is, perhaps, the main reason that designers tend to be solution-focused rather than problem-focused (Lawson, 1980). They use conjecture to arrive at solutions that contain the problem within manageable bounds.

> The essential step is to recognize that nobody, least of all the chief designer, has, at the start, the knowledge to say how the design will turn out, or even what the problem really is—how it will seem when, eventually, everyone's intuitions become informed by the experience of having designed it. At the start, one's intuition is likely to be wrong, informed by what is, but not by what is conjured into existence. (Jones, 1979, pp. 33–34)

It is important to recall that the ill-defined nature of a design problem is not necessarily a condition contained within the problem itself. As stated earlier, the designer must hold the perspective that designing is required. For example, it is possible for the building problem above to be treated as well-defined. A blueprint for the building could be generated by a computer using a set of formal rules or algorithms. A single "best" solution would be obtained—"best" to the extent of the program's capability. This method would strike Jones and others as something other than designing. The reverse could occur with the mathematics problem. The student could seek a new and elegant proof for the solution, i.e., he or she could treat the problem as ill-defined, changing it to one which requires designing.

This points out that design problems must be *found* as well as solved (Lawson, 1980), and since individuals interpret and understand problems differently (a condition that is unavoidable for ill-defined problems), it is accurate to say that each individual solves a different problem rather than just generating a different solution to the same problem.

> For us, design is a type of problem-solving in which the problem-solver *views his/her problem or acts as though* there is some ill-definedness in the goals, initial conditions, or allowable transformations. (Thomas & Carroll, 1979, p. 5; italics added)

In designing, problem understanding and problem solving may be simultaneous or sequential processes. Systems engineering models (or, more generally, systematic methods) typically call for complete understanding of the problem prior to solution efforts (e.g., Pahl & Beitz, 1984). A series of formal stages or steps are engaged in, one after the other, and a description of the problem and a definition of goals are completed at the end of the "problem definition phase." Robinson (1986), Allen (1988), and others argue that this severely restricts the designer's ability to understand the problem. They feel that, with regard to design problems, understanding is developed through efforts to solve the problem. The two processes are interdependent and simultaneous or cyclical, and goals are gradually uncovered in the context of solution attempts. As Lawson (1980) argues, the problem and the solution emerge together; one does not follow logically from the other, so the process is thus dynamic and unpredictable.

Those taking the latter view—what Robinson (1986) refers to as "exploratory" design—feel that dividing understanding and solving into two phases results in conflicts being resolved prematurely, just so that a clear definition (in the worst case, *any* clear definition) can be achieved. Studying designer's problem-solving behavior, Hykin (reported in Lera, 1983) found evidence that supports this position.

> . . . exploration of alternatives led to clearer understanding of the problem, and . . . many important subproblems were not recognised or understood, until several solutions had been attempted or pursued to an advanced stage. Therefore, properties and relationships could not be established at the beginning of the process, nor could the strategy be preselected and controlled. (p. 136)

Darke (reported in Lera, 1983) had similar results. She found that no attempts were made by her subjects (architects) to analyze in detail the requirements and their interrelationships prior to an imagined solution. She argues that requirements can only be worked out in the context of a particular solution.

In the systems engineering view, problem understanding and problem solving are carried out sequentially, and preconceptions are avoided. The solution concept is sought only after all necessary data have been obtained. This is not the case in "exploratory" design. In exploratory design, preconditions are sought and subsequently challenged. Rather than attempting to withhold judgment, the designer sees preconceptions as powerful, brings them into the open and subjects them to analysis, evaluation, and criticism (Robinson, 1986).

Both views have strengths, and both have inherent limitations. Obtaining a "complete" problem definition prior to solution activities may save the designer from wasting time working out what are eventually found to be poor solutions. But it may also "result in misdirected efforts carried out with great competence" (Holt et al., 1985, p. 109). The designer could perceive that the problem is adequately understood when that is not the case. On the other hand, an exploratory view, or what Holt et al. refer to as "soft-systems analysis," may result in a distorted definition of the task based on the differing world views of decision makers. The designer is faced with the additional task of discovering the "real need" within this context of personal perspectives and distorted information.

A basic task of designing is to convert information in the form of requirements into information in the form of specifications (Hubka & Eder, 1987). When a need for some new product is felt, the designer's job is to identify what the new product must do and to create something that will satisfy those requirements. The designer may not produce the product. More typically, he or she completes a set of specifications for the product and passes the specifications on to someone else.

In order to make the transformation from requirements to specifications, the designer needs to have learned a language or system of codes. To the information obtained from the situation, the designer adds an "ordering principle" through which "the abstract patterns of user requirements are turned into concrete patterns of an actual object" (Cross, 1982, p. 224). This language may be the basis for expression of "designerly ways of knowing" (Cross, 1982).

Design specifications can be made that meet requirements separately or as a whole. Designers often employ systematic methods, i.e., they follow a series of general steps or stages, such as problem definition, analysis, design, development, and evaluation. These methods typically involve solving problems by breaking them down into subproblems which can be understood and solved separately and then recombined. That is, rather than solving the total problem at once, the designer solves a set of related subproblems one at a time. He or she balances resources and organizes the design process according to relationships between the subproblems (Churchman, 1968), and a series of problem-solving cycles is implied.

> The overall attack on a design problem [is] often organized into relatively smaller and simpler "cycles": confrontations of portions of the total problem. . . . Each cycle addresses a specific subproblem or set of subproblems constituent to the overall design problem. (Thomas & Carroll, 1979, pp. 9–10)

Given the limits of short-term memory, this is a natural and understandable behavior, as it allows the designer to concentrate on one manageable task at a time (Newell & Simon, 1972). However, the nature of subproblems and the ways that relationships among them are retained in the solution can vary significantly. As stated above, systematic methods typically call for (1) a period of analysis in which all subproblems are defined, say, for example, by hierarchical decomposition of the problem, followed by (2) separate problem-solving episodes that address the individual subproblems, then finally by (3) recombination of solutions to the subproblems into the total solution. From this approach, isomorphic or one-to-one relationships between forms (specifications for solution components) and functions (requirements of problem components) result. As Rinderle (1986) points out, seeking and then preserving these types of relationships may lead to costly, overly large, and poorly integrated designs. The parts rather than the whole are optimized.

Alternatively, many-to-one or one-to-many relationships among forms and functions—relationships that may not be found by the systematic methods described above—may be characteristic of better designs. Rather than defining all problems prior to attempting to solve any of them, the designer may await the emergence of subproblems during preliminary solution attempts, and, by focusing on subproblems as they occur, may find a more elegant solution to the whole. Again, the process implied is much more dynamic. Cycles of problem solving are derived dynamically during the design process, vary in duration and extent, and address subproblems when and in whatever form they present themselves (Thomas & Carroll, 1979). Neither the subproblems nor the means to address them are felt to be completely specifiable at the beginning.

It is important to note that these differences in processes and consequences concern the use or non-use of systematic methods, not of a "systems approach" per se. While methods may prove limiting, thinking of problems and solutions as elements of systems may be important to generating elegant and effective designs. Still, as Kerr (1983) points out, designing ultimately involves personal choices based on a sense of what is right. A systems approach is not itself a mechanism for making these decisions and may provide only a framework in which the decisions can be made (Nelson, 1988).

The design process is a learning process. By engaging in design, the designer discovers what he or she knows and does not know about a problem and its solution. Filling that gap is a learning process. In a sense, each action taken generates an answer to a question and enables the next question to be posed (Jones, 1979). Design can thus be thought to occur as a knowledge-building cycle in which the designer makes hypotheses (predictions relating the anticipated outcomes of each action with features of the design product), challenges them, and develops arguments to support them (Robinson, 1986).

The design process is one of devising and experiencing a process of rapid learning about something that does not yet exist by exploring the interdependencies of problem and solution, the new and the old. (Jones, 1979, p. 31)

Designing involves technical skills and creativity, rational and intuitive thought processes (Hubka & Eder, 1987; Nadin & Novak, 1987; Lawson, 1980). While various authors emphasize different processes, some balance of technique and creativity seems to be necessary. For example, technical skill and rational thought processes are required to analyze the situation and to identify requirements, while creativity is important in coming up with ideas for the new product. Several authors have addressed the combination or balance needed.

The truly creative scientist needs something of the artist's divergent thought to see new possibilities while for his part the artist needs to be able to apply the single-minded perseverance of the scientist to develop his ideas. What makes design such a challenging task psychologically is the very even balance of these two sets of mental skills that are needed to produce creative work. (Lawson, 1980, p.116)

In designing, this difficulty [in solving problems] appears as the separation of the rational from the intuitive, the practical from the creative. But the briefest study of how the most successful artists, engineers, etc. work and think suggests that they have one thing in common: they have found ways of avoiding this split, of combining reason *with* imagination, of being both creative *and* practical, of knowing when it's rational to be irrational and when it's rational to work by experience. To reconcile what seems to be opposites, to resolve contradictions, is the essence of design. (Jones, 1979, p. 33)

While studies of designers' thought processes have been performed (e.g., Allen, 1988; Lawson, 1980; Thomas & Carroll, 1979), the specific combination or combinations of skills required for designing are not clear and at this point are matters of speculation. Characterizing the process as a whole, Jones (1970) illustrates three possibilities through a series of metaphors which match the historical trends described earlier. The field has moved from a concept of the designer as a magician, where the process depends on creativity, to a concept of the designer as a computer, where logic is paramount. These are not unlike the "black box" and "glass box" conceptions of the mind in psychology. More recently, a concept of the designer as a self-organizing system has become popular (as has a similar conception of mind, or rather, of what it means to know and learn—see Bednar, Cunningham, Duffy, & Perry, 1991). Design expertise is thought to lie not only in knowledge and skill, but in the designer's ability to reflect on his or her own actions. Rather than being a magician or computer, the designer must be a self-organizing system capable of controlling both rational and creative processes, knowing when to apply each and varying strategies and tactics as the situation demands.

Design is carried out as a reflective conversation with the materials of the situation (Schon, 1983). The designer as a self-organizing system must reflect on his or her actions. She or he takes certain actions, which are reflected back by the situation. The designer then assesses the consequences and implications of those actions and decides on further actions. Each set of actions is an experiment that changes the situation, frequently in ways that are unanticipated. The designer allows herself or himself to be surprised and responds with redirected actions.

By "reflection-in-action," a designer therefore spins out a web of moves, each based on "backtalk" from the situation. This conversation begins at the start of the design process, when the designer develops an understanding of initial conditions, and continues through to the proposed solution. It guides the designer as he or she reframes the problem, representing it via a chain of inferences, and as he or she hypothesizes and tests solution strategies. It helps the designer relate the current situation to experience, i.e., to see the problem at hand as similar to another problem encountered previously. Importantly, reflection-in-action does not bring the designer to fixed understanding, but rather serves to lead inquiry forward. Designing as reflection-in-action is thus an intelligent activity, and one in which knowing *how* and knowing *what* (what Anderson, 1976, refers to as procedural and declarative knowledge, respectively) cannot be separated.

Allen (1988) makes a distinction that relates to Jones' self-organizing system and to Schon's "reflection-in-action." She speaks of *situated* *designing:* "a view of activity which recognizes that the unexpected things in the path are not only obstacles to be overcome, but also opportunities for new views on the problem, and can produce new elements for the designer to use in forming the next action" (p. 12).

A "situated action" is an action in response to the current situation being encountered (Suchman, 1987). Its function is not, however, only to respond to a stimulus. It serves to shape the situation for subsequent decisions, and it does so in ways that are not entirely predictable. Thus, the environment (situation) is dynamic, not static, and each action is formed in terms of the effects of previous actions. This is what distinguishes a situated action from a plan. A plan is fashioned prior to, rather than during, a series of actions. Those who rely heavily on plans assume that the path that needs to be taken is predictable. Plans may therefore be more consistent with a "rational" view of designing, one that sees problems as well-defined, while the concept of situated designing may be more consistent with a "creative" view, one that sees problems as ill-defined. (Note that "plan" is used here in reference to the means of designing rather than the ends. A design is itself a plan for change, but the design *process* does not necessarily follow a plan.)

To some who appear to take a predominantly rational view (e.g., Martin, 1984), a reliance on creativity exists for controlling rational processes. This might be taken as a concession that not all aspects of the process can be predetermined. Regardless of the view taken, some level of situated designing, and of reflection-in-action, is apparently necessary for designers. In a sense, reflection-in-action may describe the process of controlling situated actions (or, perhaps, of following a plan), and the mind engaged in both is a self-organizing system.

Design models reflect idealized views. The definition and descriptive statements above were based primarily on studies of the design process. It is important to emphasize that these studies represent only a small portion of design literature, and at times they contradict what the main body of literature purports. As was hypothesized earlier to be the current state regarding ID, *much of the literature on design does not reflect practice.* Both in prose and in graphic models, design is portrayed in ways that studies of design processes (i.e., studies of practice) suggest are idealized. For example, the typical view in engineering remains one in which design is described as a systematic and rational decision-making process that occurs as a linear sequence of steps or phases (e.g., Luzadder, 1986). In contrast, some architects refer to design as a creative process which occurs as a series of cycles and depends more on opportunities than plans (Hubble, in Marshall & Kifer, 1989). When the processes engaged in by these engineers and architects when designing are studied, these predominantly "rational" or "creative" views essentially disappear. Different objects are created, different goals and criteria are set, and therefore different decisions are made, but the underlying processes are similar. As discussed above, how well- or ill-defined the problem is, and in particular the designer's perception of how well- or ill-defined the problem is, may be most important. Idealized views given in the literature may be held, but at this point it is not clear what influence they have on how designing proceeds.

ID AS A TYPE OF DESIGNING

Designing instances of instruction, or more generally, planning and preparing to instruct, can be considered a subset of designing, and the defining characteristics described above for all types of design appear to hold true for ID. Instructional design is directed toward the practical purpose of learning, i.e., the designer seeks to create new instructional materials or systems in which students learn. To do this, he or she attempts to develop an understanding of the *conditions* and the desired *outcomes* of instruction, and to use this understanding in specifying *methods* (Reigeluth, 1983).

As in other fields, instructional-design processes vary, depending on what is being designed. For example, different tools and techniques may be employed, depending on whether a new system or a performance improvement is involved or whether a single piece of instructional material or an entire curriculum is to be created.

Social interaction is important to instructional design. In order to determine requirements and create effective methods, the designer must work with the clients and sponsors of projects, subject-matter experts, producers and actors, teachers and learners.

Instructional problems can be seen as well-defined or ill-defined. That is, the designer may interpret the initial information regarding conditions and outcomes as accurate and complete, and may see a simple path to an effective instructional method. In contrast, another designer might see the same situation as poorly defined by that information and have considerably less faith in solution ideas.

Effort to understand an instructional problem (or opportunity for learning) may precede consideration of methods, or methods may be considered simultaneously. In the former case, the designer first seeks an understanding of the problem (determines conditions and outcomes) then proceeds to solve it (selects methods). In the latter case, ideas for instructional methods may help the designer understand the problem. That is, if method X seems to be a good match, then the situation is more likely to contain a problem of type X. In either case, methods can be matched to conditions and outcomes in an isomorphic fashion or with many-to-one or one-to-many relationships.

Lastly, instructional design clearly involves rational and creative or intuitive thought processes. Less clear is how, when, and for what purposes either type of process is or should be emphasized. Also unclear is the extent to which instructional design represents a "reflective conservation."

TWO VIEWS OF INSTRUCTIONAL DESIGN

While authors agree that instructional design involves a combination of rational and creative thought processes, they tend to accentuate one or the other extreme. Some individuals take a "rational" view and describe instructional design as a technical process in which designing is driven by known rules, principles, and procedures. The designer operates in a step-by-step manner, extracting some standard types of information from the situation, clearly defining goals and objectives, and deriving an "optimal" design. The process is logical, rational, and systematic, and the designer can be likened to a technician or perhaps to an engineer. This view underlies many systematic models (e.g., Dick & Carey, 1990) and can be taken to represent an underlying belief in the prescriptive power of a science of instructional design.

> Instructional design is [a] linking science—a body of knowledge that prescribes instructional actions to optimize desired instructional outcomes, such as achievement and affect. (Reigeluth, 1983, p. 5)

> Instructional design can be defined as *the science of creating detailed specifications for the development, evaluation, and maintenance of situations which facilitate the learning of both large and small units of subject matter.* (Richey, 1986, p. 9)

Although in the minority, other individuals describe instructional design as a creative process in which designing is driven by the recognition of opportunities and is carried out in iterative cycles. The designer interprets needs and identifies potential strategies in the context of the specific situation at hand. Standard rules or procedures are not employed, as they are felt to be based on a reduction or oversimplification of factors affecting the instructional system. The process is intuitive, creative, or artistic, and emphasizes early attempts at solution rather than complete understanding prior to solution attempts.

> Design is a creative, disciplined, and decision-oriented inquiry that aims to: (a) formulate and clarify ideas and images of alternative desired states of a system; (b) prepare descriptions, representations or 'models' of the system; and (c) devise a plan for the development and implementation of the selected (most promising) model. (Banathy, 1987, p. 89)

> Thinking up a design for a course or lesson is an intuitive, creative and logical process. Since it is a creative process it will not run smoothly from beginning to end. . . . An experienced designer soon learns to "sense" when she or he is on the right or wrong track. This is *intuition* at work. Richness of ideas, ingenuity in seeking a solution to the problem (the choice of optimum design), and originality come from the designer's *creativity.* The disciplined weighing, testing and selection or rejection of ideas is based on goal-directed *logical thinking.* Intuition, creativity, and logical thinking are at work in a designer's think tank. (Earl, 1987, p. 32)

All four authors quoted above would likely concur that design is not simple and that it requires high-level cognitive processes. The nature of those processes, however, is in question. Reigeluth and Richey place emphasis on rationality, on the importance of following rules and procedures. They feel that design principles accurately predict future phenomena—in this case, learning—and therefore can be used to prescribe instructional events. In this sense, design is a science when an understanding of principles is sought, and is closer to engineering when those principles are applied. The design practitioner would function primarily as an "engineer."

Banathy and Earl place more or equal emphasis on creativity, suggesting the importance of artistry and the subjective. Individuals taking this view argue that prescriptions are not useful. Congruent with perspectives on design in other fields (e.g., Jones, 1970; Schon, 1983), they feel that the phenomena with which designers work are so complex, involve so many variables, and are so uncertain that the designer must treat each design as a unique case, not a recurring event. The design product and the design process are bound to context. The "artist" or creative instructional designer sees rules and procedures as having limited application. He or she practices a craft or art in solving problems.

SOME PRELIMINARY FINDINGS

These discrepancies in the literature between views of what ID is beg the question, How do ID processes actually occur? Kerr (1983), Nelson (1988), and Rowland (1992) have asked this question and have found that, as suggested above, the thought processes engaged in by designers in the act of designing instruction are well predicted by neither the "rational" nor "creative" views in the literature. Results, however, do correspond to those from studies of design processes in other fields.

Some key results reported by Rowland (1992) include the following:

- Expert instructional designers appeared to interpret and treat problems as ill-defined. Designers in the study took a skeptical posture toward "given" information, seemed to believe that conditions and outcomes do not entirely determine methods, and continued to question the adequacy of solutions even after development.
- Expert instructional designers appeared to delay working out the details of solutions pending a more complete understanding of the problem, but generated solution possibilities very early in the process. These solution ideas seemed to constrain the process and to serve as a joint context in which problem understanding occurred. That is, both problem and solution were matched to integrated problem-solution patterns in memory, some retrieved via specific case experiences.
- Rather than responding yes or no to whether the problem was instructional in nature, expert designers explored, and appeared to consider within the scope of "instructional design," a variety of problem and solution possibilities. Many different causal factors relating to the performance of individuals and the organization were considered, and a range of instructional and non-instructional interventions were specified.
- "Scientific principles" of instructional design may have served as heuristics for deriving a solution or for evaluating previously imagined solution ideas. It was rare for a designer to make a clear prescription of method from a small set of known factors. More common was a "rule of thumb" being used to select a type of solution or to evaluate the quality of a particular idea. In doing this selecting and evaluating, "global" as well as "local" criteria were applied (i.e., a wide range of systemic factors were considered).
- Expert processes were better characterized as situated actions taken in response to moment-to-moment conditions than as predetermined steps. While a general plan was evident (at least in retrospect), decisions on how to proceed were made on an ad hoc basis with respect to the goal of a solved problem rather than with respect to a formal plan for how to solve it.

These results match studies of design processes in other fields, but contradict views in the literature on ID, especially those representing a purely rational perspective. Even what designers considered to be a relatively simple problem was interpreted as ill-defined. The notion of gaining "complete" problem understanding before trying to solve—something implied in most ID models—was contradicted by the almost immediate consideration of solutions. The yes/no decision of entry into ID processes, also typical of ID models, did not occur. Use of instructional-design principles was not evident, and adherence to a formal plan (e.g., a sequence of steps to be taken) was not observed.

Of course, these results are from a single study which used a single design problem and a small group of designers. Other studies that test questions raised by this work are needed. For example, the utility of current ID models could be tested in ways similar to Higgins and Igoe's (1989) test of media selection models. Perhaps current ID models do not adequately reflect or support design processes, but do serve important pedagogical, communication, and/or management functions.

SUMMARY

In this article, an attempt has been made to synthesize design characteristics from a number of fields. The synthesis is offered as a starting point, a perspective from which to re-examine our views of ID. Significant overlap between ID and other types of designing seems to exist, and the attributes described above can be seen to hold for instructional designing. Preliminary research suggests this to be the case and indicates that important differences exist between traditional views of ID and actual practice. However, much work remains.

Instructional technologists have begun to examine more carefully what other design fields have learned. Tripp (1991) explores views of design as optimization (Simon, 1981) and design as dialogue (Schon, 1987), then relates those views to ID. Streibel (1991) considers situated actions in relation to the design and use of instructional systems. Others have examined the thought processes of individuals engaged in designing instruction (Kerr, 1983; Nelson, 1988; Rowland, 1992). And alternatives to the deterministic, rational view of ID have appeared (e.g., Banathy, 1991; Carroll, 1990). A great deal more effort in these directions is needed, and a much better understanding of what ID processes involve is required. We should not expect that understanding to translate directly from other fields, nor should we limit our view to what we can see through our own lens, i.e., to what is seen from a self-directed, closed perspective. Sharing of knowledge between design fields, including the field of instructional design, is especially important. □

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