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ABSTRACT

The literature on instructional design argues that curricula, educational materials, and instructional strategies are best created using a systems approach, and models for the systematic design of educational programs have proliferated over the past decade. However, these models are prescriptive and not based on research into how designers actually think when they approach a design task. A summary of theoretical and empirical studies from the fields of art, architecture, and artificial intelligence which were examined for their relevance to instructional designers introduces a study of design activities among 26 novice instructional designers. This study investigated (1) the prevalence of initial generation of multiple design solutions; (2) the basis for acceptance or rejection of candidate solutions; (3) the constraints encountered in executing the design; and (4) how designers knew the design was finished. Results indicated that novice designers have difficulty entertaining multiple possible solutions, especially for more than a few steps into design work. They eliminate alternatives rapidly and are not proficient in representing design problems to themselves or to others. They have trouble determining a reasonable stopping point. This paper includes a 12-item reference list and tables of study data. (Author/LMM)

Inside the Black Box: Making Design Decisions for Instruction

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Abstract

The literature on instructional design argues that curricula, educational materials, and instructional strategies are best created using a "systems approach." Models for the systematic design of educational programs have proliferated over the past decade. But these models are prescriptive and not based on research into how designers actually think when they approach a design task. Important theoretical and empirical studies from the fields of art, architecture, and artificial intelligence are summarized here as a prelude to presentation of findings from a study of design activities among a group of 26 novice instructional designers. Among other things, the study investigated: (1) the prevalence of initial generation of more than one possible design solution; (2) the basis on which candidate solutions were accepted or rejected; (3) the constraints encountered in proceeding with the design; and (4) the way in which designers knew that they were finished with the design. Results indicate: that novice designers have difficulty entertaining multiple possible solutions, especially for more than a few steps into design work; that alternatives are eliminated very rapidly; that designers are not proficient in representing design problems to themselves or to others; and that they have trouble saying what a reasonable stopping point is. Suggestions for further research, and for contributions that ID might make to the ongoing research effort on human problem solving, are presented.

Inside the Black Box: Making Design Decisions for Instruction

What do we do when we design? The question has long been a puzzle for philosophers and psychologists concerned with aesthetics and creativity. More recently, engineers, architects, and commercial designers have also become interested in how humans select elements from a large universe of possibilities and combine them to form a solution that is both functional and at the same time pleasing to the senses. For such professionals, the notion of design is inextricably linked to the notion of quality; the purpose of design is not merely to select <u>some</u> combination of elements that contribute to a solution, but to select a <u>better</u> combination, one that seems simpler, more functional, more aesthetically satisfying, more elegant.

Those working in the field of instructional design (ID) often discuss their work in similar terms: identifying a wide range of educational strategies and materials that <u>might</u> contribute to the solution of a design problem; setting up criteria for the elimination of some elements and the selection of others; and making design decisions in light of those criteria. What is not clear is just how those choices of one medium or strategy over another, ceteris paribus, are made. What, in other words, goes on inside the "black box" of the designer's consciousness when solving an instructional problem? And would it make any difference if we knew?

My purpose in this paper will be to: (1) briefly review the models of instructional design (ID) found in present day literature and identify some problems common to those models; (2) provide an introduction to the issue of design _qua_ problem-solving activity as seen in work currently being done in art, architecture, and artificial intelligence; (3) present data from an empirical exploratory study of how novice instructional designers cope with making design decisions; and (4) speculate on the implications of the observed results (and the work being done in those other fields) for ID--what ID is, how ID workers might be better trained, and how they might better perform their roles.

The Contemporary Model of Instructional Design

It is difficult to identify a single model of ID in the current literature. Each author seems to prescribe a process that has at least some distinctive elements. Nonetheless, there are a number of general features that most of these models share in common: the use of algorithms or flow diagrams as a way of suggesting the steps to be taken and the order in which to take them when making instructional decisions; a concern for evaluation of programs while they are under development and for their subsequent revision; and, most importantly for our discussion here, an insistence that the aims of instruction be well specified, that strategies and materials be developed with those aims in mind. It is this latter point--the development or selection of instructional strategies and materials--that I want to discuss further here, for I see this as a key problem for ID.

Few would argue that the identification of which materials or strategies to use lies at the heart of ID. Even with the best of charts, tables, and decision trees, there are still likely to be many possible answers to the question, "What instructional approach should I take?," for any given situation. And so it is at this point that the instructional designer's abilities as a designer are most on view.

The treatments of this critical point of selection in most of the standard ID sources make the procedure look deceptively easy. Witness several of these:

> There now comes the point at which all events must be brought together to make up a successful lesson. The designer now considers the practicality of using all the theoretically best media.... The designer visualizes the instructional environment to determine whether so many media are used that they may create management problems in the classroom, or so few that they may produce monotony for the learners. Surely one would not wish to change media for each instructional event in the series, nor to allow attention to lag because of an overuse of one medium.
> The designer considers the practical factors...as well as the nature of the learners and the nature of the lesson's objective.... In making this series of decisions, the designer aims: (1) to stay within the resources and constraints of both the media... available and the classroom environment, (2) to use a medium long enough for efficiency but to aim for interest and effectiveness, and (3) to make good use of the capabilities of the media. (Gagne & Briggs, 1979, pp. 190-191)

To apply a systematic model of media selection, we will be concerned more with first identifying essential media characteristics rather than with a search for the 'ideal medium.' This will limit our choice considerably. Then we will proceed to eliminate from this short list any media which are impractical, unavailable, or do not conform to those optional media characteristics which we love most dearly. In this way we will progressively limit our choice more and more closely: 'selection by rejection' will be our motto. (Romiszowski, 1974, p. 65)

Components of a learning system are selected on the basis of an evaluation of their capability to accomplish functions required for the mastering of learning tasks. (Banathy, 1968, p. 69)

Not all media seem to be as well adapted to a given lesson content and [this] suggest[s] that one should match media choice to the particular lesson content or the objectives of the lesson. The problem is how to do this. This has led to complex systematic schemes for the analysis of individual learner differences, in how they react to different media and schemes for the analysis of lesson content so that it can be matched to appropriate media and so on. Some of these schemes have proved to be rather difficult to use in practice and certainly difficult to teach to all teachers, so we are going to steer a middle course and try to suggest some basic rules which might be applied in order to:

1. Eliminate any media which would be quite inappropriate for a given lesson or part of a lesson. We use here the

principle that an appropriate medium should be capable of supplying all the stimuli essential for learning....

2. Select from the short list of media left, on the basis of the economic and practical constraints and teacher and learner preferences and skills. (Romiszowski, 1981, p. 340)

A recent survey of instructional design models further highlights the importance placed on strategy and media selction in most models. Of 40 models examined, some 34 were found to deal explicitly with selection of strategies, and 24 with selection of media. The only ID tasks included in this group of models with greater frequency were specification of outcomes and tryout and revision of courseware (Andrews & Goodson, 1980).

Now there is really nothing that can be said to fault the descriptions of the selection process cited above, at least insofar as they go. But the problem is that they do not go far enough. While ID algorithms and decision tables attempt to outline the realm within which the designer's actions take place, they tend not to provide a clear picture of just how the designer operates during those few crucial minutes or seconds when the heart of an instructional solution first appears. The process, in other words, is made to appear overly mechanistic. Although there are a few caveats, the process is made to appear one of filling out the right tables and identifying all the constraints, rather than one of making decisions that may ultimately be personal and based on some ineffable sense of "what's right" in a given context. (Let me note as an aside that I realize that few instructional designers or authors in the field would maintain that the entirety of the process of design is actually well represented by algorithms and flow diagrams. What I do sense from several years of teaching introductory and advanced ID courses, however, is that students often have trouble grasping this from the ways ID texts present the crucial steps of media and strategy selection.)

What we seem to have, then, is a model of design in only a weak sense. The conditions surrounding design decisions--needs assessment, task analysis, specification of objectives, and evaluation and revision procedures--are treated in great detail. The sense of precision imparted by charts and tables may lead the novice coming to the process for the first time to believe that the steps that ID texts prescribe to reach a design decision are sufficient, when in fact they are only necessary. After the universe of possible choices is described and then limited by awareness of all the budgetary and time constraints, all the knowledge about student and instructor background and predilections, there still may be more (and quite often many more) than one feasible approach remaining when all the heuristics provided by the model have been exhausted.

A strong-sense model of ID would offer not a precise recipe for how such decisions are to be made, for that is likely impossible given the nature of the problem. Rather, it would provide a picture of how designers as individual problem solvers approach those "black box" tasks of conceiving a universe of possible solutions, narrowing the solutions down to a manageable few, and making a final choice. Having such a strong-sense ID model available would contribute to a growing base of knowledge about how humans work as problem solvers and creative designers; it might also make it easier to train those who will actually work as instructional designers.

Perspectives on Design as Problem Solving

Where might we turn in searching for ideas on the nature of design as a problem-solving activity? Some relevant work has recently been done in the field of education. Other studies from art, architecture, and artificial intelligence may also contribute some valuable insights.

Teachers as designers. There has been a recent flurry of interest around the question of how classroom teachers actually plan for instruction, think while teaching, and modify instructional decisions based on feedback received during classes. It is not my purpose here to review this research in depth, for other surveys are available (Kerr, 1981; Shavelson & Stern, 1981). But a few key points should be noted here. First, instructional activities in day-to-day teaching most often flow from an early specification of general objectives followed by more immediate generation of an image of how the classroom should operate; preparation and use of concrete objectives on a daily basis is comparatively rare. Second, an initial selection of materials or strategies is often the critical decision for how a particular class will run for a day, week or year; curriculum and objectives tend to come from materials, not the other way around. Finally, and most important for the purposes of this paper, there has been very little research on the particular tactics instructors use when they come to the point of actually designing and selecting media and teaching approaches.

Artistic design. The design of a work of art likely differs in many ways from the creation of a sequence of instruction. Nonetheless, there do appear to be some commonalities. Artists and artisans have recently begun to publish discussions of how a design develops and evolves; one interesting such exploration is by Needleman (1979). And Harrison's (1978) fascinating analysis of how artists operate when they "design while making" warrants special consideration here.

Harrison notes that the artist faces a critical problem almost from the beginning: "How does the maker of the artifact recognise that his work is done, that the thing is made?" (p. 124). Since most artists do, at some point, put down brush or chisel and declare themselves finished, there must be a growing sense of purpose as a designer proceeds. That sense of purpose expresses itself in terms of a series of choices and the artist's preferences between the alternative design elements he imagines. Those preferences, however, become progressively more constrained as the design evolves and as the effects of previous choices narrow the range within which decisions can be made. The "design becomes complete when there is no further room for manoeuvre" (p. 137). Such an effort Harrison characterizes as "free design," in which a definitive goal is not present from the start, and in which the designer's vision is always in a sense "to the rear" toward decisions already made and preferences already incorporated in the design.

An alternative approach is what Harrison terms the "means-ends project," a design effort in which a definite goal is in view, and in which entire sequences of actions are considered separately before starting. Here, the designer's view is forward-looking, focused solely on what is to be achieved. A combination of "free" and "means-ends" design approaches yields a "closed means-ends lozenge" in which an aim is known, but precisely how to achieve that aim must be worked out as one proceeds. The free form, however, "represents the most primitive system of practical intelligence in the sense that it underlies any more sophisticated thought in action" (p. 140).

Harrison's key point, then, is that "free design" is somehow a necessary precondition for any more ordered method of designing. And the ability to tell when one is finished--or at least to recognize when further elaboration would only spoil what has already been done--is a critical feature of that elementary approach to design.

Architectural design. A different view of design may be seen in recent work on how architects work. Sundor (1980) gives a useful summary of some of this work. Eastman (1973), a pioneer in this field, notes:

> Just because a methodology is explicit does not mean it is superior to intuition. Little is known about what makes a superior designer or a superior design process. By comparing processes and what they produce we may learn the unique capabilities of the superior designer. (pp. 21, 23)

Eastman uses an information-processing model of thinking in conjunction with recorded protocols of architects thinking out loud while designing (a method also commonly used in the teacher thinking research) to investigate intuitive design practices. In one study, architects were given a problem--to redesign a bathroom that was perceived by potential house buyers to have certain basic flaws. Several common features were observed in the ways architects attacked the problem. First, most viewed the problem as one of "designing a bathroom" rather than "correcting errors in an existing design." Second, all the architects proceeded by first selecting a design element (e.g., position of the wash basins) and testing its qualities, rather than by first specifying an abstract set of relationships among the various possible elements. Third, in testing elements, four kinds of mental operations seemed to be involved: (a) logical manipulations, including arithmetic and verbal logic; (b) corroboration and possibly expansion of information by gaining similar information from another source; (c) manipulation of or application of a constraint to the current information to produce a new form; and (d) association of a manipulation with a constraint (e.g., location of a partition to provide visual privacy). Finally, the architects automatically sorted the design problem into two phases, one in which the major elements were treated as a "stack," or "deck of cards"--each element was manipulated by trial and error, followed by a test to see whether constraints were met--and a second phase in which smaller aesthetic touches were added (e.g., placement of towel racks).

Eastman found that the method of representation used (words vs. symbols, overhead views vs. cross-sections) influenced the way in which and speed with which a solution was derived. Those designers able to see more different ways of representing the problem appeared to be more successful in less time than those who used fewer ways of viewing the problem.

A second finding was that designers who had in memory well-organized "packages" of constraints associated with particular design elements seemed to be more successful in a shorter time than those who had to rely on external aids or descriptions to generate constraints. Eastman noted, "We tend to assume that designers utilize all the information mentally available. It can be shown, though, that designers are quite at the mercy of a fallible memory" (p. 30).

The essential points of Eastman's study of architects as designers, then, are that the initial problem-solving step is likely to be the test of a particular design element, that there is a logical order in which possible design elements are tested for fit, that the representational language used affects the rapidity and quality of the solution, and that the ability to call up readily constraints associated with particular design elements also aids in finding a solution.

Design in artificial intelligence. Herbert Simon offers a further perspective on the process of design in his The sciences of the artificial (1981). Although starting from a base in computer science, Simon makes it clear that he is concerned with design in general--"how to make artifacts that have desired properties" (p. 129).

Simon describes the search for a solution to a design problem as a process of maximizing the utility of "command variables" (or means), given a particular combination of constraints (ends) and "fixed parameters" (laws). The way one does this is to "consider all possible worlds that meet the constraints" (p. 136), and then identify the particular world that maximizes utility. Such a process attempts to find the best possible solution to the design problem; he terefore terms it an "optimizing" decision model.

Unfortunately, real-world conditions are usually too ill-defined, or involve too many complex variables, to allow one to find the one best solution (or to be sure one has found it when one thinks one has). In such situations, we search for a satisfactory solution, a solution that will be acceptable and entail "only moderate search."

Given the large number of elements that must be taken into account in searching for a solution to a design problem, the process is rarely one of mere assembly, more often one of search for an appropriate (though likely not a "best") combination of elements. One is not sure, especially at the start of a search, which of the many possible solutions is likely to work out, and so part of the search strategy is to collect and store information with respect to one possible solution with the idea that one may need to recall it later with respect to another possible solution. The designer must also calculate the costs of exploring various options and figure these into decisions about which possibilities to investigate further and which to discard.

A critical step in the initial part of the design cycle is figuring out how to "decompose" the entire problem into a set of related sub-problems. While this may be helpful, it further adds to the complexity of the solution, for there may be many alternative ways of decomposing the problem. The way of representing the problem (verbally, mathematically, diagrammatically) may also have an effect on the way in which these alternative decompositions are generated.

The design process then becomes one of "first, the generation of alternatives and, then, the testing of these alternatives against a whole array of requirements and constraints" (p. 149). Each set of alternatives may be generated by a different way of decomposing the problem, and these generate-test cycles may be nested within one another. The solution comes when the designer obtains a set of alternatives that meets all the constraints, that leads to the desired ends, and that conforms to the fixed parameters of the situation. Those elements must be connected (or connectable) to one another, and they must represent a satisfactory (though probably not "the best") solution to the problem.

The particular insights that Simon's model offers are: first, that the designer usually must try for merely satisfactory, rather than optimal solutions; second, that the designer, while searching for that satisfactory solution, must take this uncertainty into account by exploring alternate paths, and by storing and reexamining information on each of these as the design is developed; and third, that decomposing the problem into a set of related sub-parts is a desirable strategy to use in seeking a solution, but that there are different ways of doing that decomposition, each of which may lead to a different set of alternatives to be tested.

What three diverse approaches to design suggest. The three approaches to design presented and discussed here stem from quite different traditions. Harrison's treatment of artistic design is focused on the development of pattern and form in an environment that is very free and constrained only by the need to define an end, a point beyond which further elaboration would merely detract from the final product. Eastman and Simon both concentrate attention on the sequential aspects of problem solving in design and on the question of how design problems are represented internally by the designer. But Eastman's approach deals more with the manipulation of individual elements within the context of a bounded problem, while the latter places his emphasis on choices among alternate design paths.

A Study of Instructional Designers' Thoughts

Are the general descriptions by Harrison, Eastman, and Simon of how designers work applicable to the situations instructional designers face? Can we learn anything about ID by using some of the theoretical principles they propose? In an effort to find answers to these questions, I conducted a further study of how novice instructional designers approach their tasks. (For several earlier exploratory studies, see Kerr, 1981.)

Methodology. The subjects in this study were 26 students in a graduate-level introductory course on ID. The subjects' backgrounds varied considerably--several had already worked in the field of ID for a number of years, others had been exposed informally to ID through work in publishing companies or educational broadcasting facilities, while perhaps half the group had no prior experience with ID. Most in the group had taught at some point, although levels varied from early childhood through college and included such diverse settings as special education and business-industrial training.

During the first part of the course, the students were asked to decide on a design project to be elaborated as the course progressed. The instructor collected an initial statement of the topic, "candidate media," and constraints that students felt they would need to overcome; students completed this statement by the second class meeting. During the sixth class meeting, students submitted a preliminary design and the instructor interviewed each of them briefly. The interview dealt with four aspects of the initial design process: (1) the presence or absence of alternate design solutions for the problem on which the student chose to work; (2) the method of selecting the particular solution the student chose to elaborate; (3) the constraints that the student considered or encountered (especially as compared to those identified on the statement of initial topic choice); and (4) the presence or absence of a definable end point to the design effort.[1] Following the interview, the investigator amplified the notes on each schedule using tape recordings of the interviews. Responses were then collated onto single coding sheets and categories developed using simple content analysis procedures. I will deal with each set of results separately below.

Multiple solutions. The first question asked students, "As you thought about the topic that you worked on in this project, did several possible solutions (combinations of specific objectives and media/techniques) occur to you?" Table 1 shows the responses students gave to this question.

Table 1 about here

Most of these novice instructional designers clearly did consider more than one possible approach to their topic--even among those few who indicated that they did not, two of three said that others might have done so. The interesting aspect of these responses is that relatively few of them (9), even with a prompt, were able to say much about the other alternatives they had at first considered. The preliminary choices, then, of a general approach to take, what objectives to pursue, and how to present material, appear to be made very early on, perhaps without the subject's even being aware that some initial selection and discarding of options has already occurred.

Among those 9 who were able to discuss their initial mental states in more detail, only a few indicated that they had really proceeded in "systematic" fashion (in spite of repeated injunctions from the instructor that they do so, a series of explicit textbook models of systematic ID procedures, and a required needs assessment!) These few differed among themselves in how they worked. One said, "I just started listing [options]," while another offered, "I made a chart, then cancelled the trivia and [approaches] I thought were too hard." A more-or-less visible ID strategy was visible in one response: "I thought of the subject first, then [developed] measurable objectives, then [considered] media." But, of the entire class, this group was a minority.

Winnowing the possible solutions. The second question required students to describe how they decided which design elements to keep working on, and which to discard. The results are presented in Table 2.

Table 2 about here

The most interesting thing to emerge from these figures is the very strong weight these novice designers apparently place on their immediate working environment. They often cited their own experience (38%), the needs of their students as they define them (35%), failings of existing methods or approaches (27%), and constraints of the situation (19%) as critical elements in helping to eliminate possible solutions.

Relatively fewer students (35%) indicated a desire to try a particular approach about which they knew but which they had not tried ("I wanted to use some new media"), or a need to deal with a particular subject or topic (31%). And, as with question one, only a relatively small percentage indicated that they had narrowed their focus using a careful, rational process of weighing decisions and considering the merits of the various alternatives.

Constraints encountered in working on the design. In this question, students were asked if they had to deal with constraints other than those identified in the initial topic statement. Table 3 summarizes these results.

Table 3 about here

There was a good deal of variety in the types of constraints students encountered when working on their designs. Many of these constaints had to do with the feasibility of the approach(es) chosen. Students seemed basically to be asking, "Will the financial, administrative, and social supports needed to carry out this project be available when it is eventually finished?" In several cases, the choice of project design was apparently influenced by previous failures in similar areas. A further situation-specific constraint had to do with the meaningfulness of the content or the approach to students; one designer indicated, "[I needed to] formulate in my mind what the student would be thinking of, what was going on in the student's mind." Others admitted to difficulties with subject matter or topic selection (12%).

These novice designers identified a separate set of constraints in the ID process itself. Fully 35% reported problems in defining objectives or specifying measurable outcomes, and some had further problems. One expressed frustration with having to "stay to safe objectives," while another wondered "how to design a project when you already know what you want to use?"

"When were you finished?" The last interview question was also the shortest: "How did you decide when you were finished?" The question was, to say the least, an unexpected one; many of the students broke into laughter on hearing it, or made animated remarks such as, "That's a good question!" These results are shown in Table 4.

Table 4 about here

Clearly one of the benefits of using an ID approach is that, for many designers, it allows an end point to be more easily discerned. More than half (14, or 54%) of the students said that they knew they were done when they had dealt with each of the objectives or tasks sufficiently. (Given Simon's comments about design as a satisficing strategy, perhaps the next question to ask would have been, "What was sufficient?") Another large group (42%) indicated they felt that they were not finished, but had been forced to call a halt (many used the phrase "an arbitrary stopping point") by time pressures. Some also admitted that they had simply "burned out."

An interesting detail is the distribution on this question of those nine subjects who said in their responses to question three that they had had trouble specifying objectives. On this question, five of the nine fell into the first category ("When all objectives had been dealt with"), with only two saying they felt they had not finished. Wrestling with objectives at the start of a project does indeed seem to be a way of assuring that a definable end will be in view.

Implications of the Study

This study of novice designers' thinking as they confronted and worked with a systematic ID model for the first time offers some new insights into the design process. Certainly the use of an ID approach tends to steer educators more in the direction of an architectural or artificial-intelligence solution to design problems, in contrast to the looser, artistic, "free design" model described by Harrison. But just as certainly there are many differences between the model of how ID is supposed to work and the model as these educators and students apparently understand and apply it.

Speed of winnowing alternatives. First, the process of selecting a particular design alternative for further exploration and elaboration appears to happen very rapidly--likely within the first few days (or perhaps even minutes) of working on a design problem. And in many cases, the constraints of a particular instructional setting are accepted as being fixed and rigid, rather than seen as being susceptible to influence and change. While it is probably desirable to be able to call up and deal rapidly with sets of constraints attached to particular design elements (recall Eastman's argument), it is probably not desirable for the constraints of the existing situation always to determine the future course of action too early.

Also apropos here is Harrison's conclusion that "free design" is a necessary prerequisite to any more applied design effort, for these educators found it difficult to avoid fixing the design near the beginning of the process. The implication here is that ways need to be found to help designers maintain an open set of options for longer into the initial phases of design work.

Method of winnowing alternatives. A second important problem that arises from the results discussed above is that most designers (novices, at any rate) do not have good ways of representing the problem to themselves. Both Eastman and Simon note the value of sketches, diagrams, or formulae for dealing with a design problem. But, even with the help of texts and examples, the educators studied here found it difficult to describe and characterize how they made decisions about alternative courses of action. Perhaps more attention needs to be devoted to developing new symbol systems for decomposing problems as part of ID. Flow diagrams are probably not the universal solution we have assumed them to be.

A related problem is that most of the subjects in this investigation were simply not very aware of their own ways of making decisions. In future investigations of this sort, it might be wise to use simulations of design situations (just as many teacher-thinking researchers have used simulations of classroom teaching situations) rather than to try to capture what has happened with the sort of "stimulated recall" approach used here. A related concern is the need simply to encourage designers to be more reflexive in their actions, more aware of how they are proceeding, more conscious of their own thoughts, reactions, and decisions.

Assuring a broad range of alternatives. A third problem that this study illuminates is the difficulty of encouraging designers to hold in mind a broad range of possible design elements. As noted above, many of the subjects tended to stick with known approaches, tailored to a known situation, rather than try either to use a different approach or to restructure the situation. If one of the goals of ID is to encourage rational selection from as broad a range of potential approaches, strategies, and media as possible, then it behooves those working in the field to find ways to assure that many candidate solution elements are kept in mind, even those with which the designer may not feel personally comfortable. How to do this is another question--lists and charts seem not to be terribly effective. Perhaps what is called for is some sort of initial sensitizing experience in which the designer is not only exposed to but actually required to work with as broad a variety of media, strategies, and teaching situations as possible.

Seeing the end clearly. Finally, some attention needs to be paid to the question of how designers know when a design is done. In some relatively well-defined situations, this may be easy. But for many of the subjects interviewed here there was obviously not a clearly presented finish to the work. In any approach to design based on satisfactory (rather than optimal) solutions, there will be problems in figuring out what is satisfactory. Perhaps end-defining heuristics could be developed that would allow something to be used as a criterion other than that old stand-by, "I ran out of time."

The future of research on designer thinking. There are many puzzles that this study leaves unresolved. An essential question is how the thinking and design practices of experienced designers differ from those of novices. Interesting comparative studies might also be done to see if designers' thinking varies according to the type of problem representation they were trained to use, according to their strategies for testing solution elements against constraints, or according to other variables in the design process. Specific studies could investigate whether training in some of the specific techniques discussed here--for example, keeping a wide range of options open until late in the design project--would produce designers with a different (if not necessarily better) style of work from those trained by more conventional methods. Perhaps most fascinating would be to compare the style of those designers whose work is widely recognized as being superior with that of run-of-the-mill designers.

But this study really only marks another step in the opening phase of a research effort that has goals much broader than simply examining how designers work to develop instructional programs. The intent must be to treat carefully and systematically the question of how humans act when they deal creatively with all sorts of novel situations, puzzles, and problems. This is a challenge that involves researchers from many disciplines. In addition to the fields considered here, for example, we might profitably examine how design is conceived of, taught, executed, and evaluated in such areas as commerical product design, interior design, musical composition, writing, and urban planning. The large existing literature in the psychology of creativity and problem solving is also relevant here, and needs to be considered more closely.

In these investigations, instructional design has an advantage (though some might mistakenly see it as a disadvantage) in that it is inherently an extremely complex process encompassing a whole series of situational variables, material factors, and interaction among the various instructor and student roles. What we have to contribute is a unique set of insights into how complex designs are generated, tested, revised, and carried into practice. What we stand to gain is a reflexively conscious model for instructional design.

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Footnote

[1]Copies of the form used to collect the initial topic statement and of the interview schedule are available from the author, Stephen T. Kerr, at: Box 113, Teachers College, Columbia University, New York, New York 10027 USA.

Table 1

Was There More than One Solution?

	N	%[1]
Yes	18	69
Yes, but one was selected early	11	42
No	3	12
No, but others might have seen one	2	8
Unsure	5	19
Evidence of winnowing	9	35

[1]Total of "Yes," "No," and "Unsure" is 100%.

Table 2

On What Basis Were Candidate Solutions Selected?

	N	%[1]
My own experience	10	38
Student needs	9	35
Desire to try a particular approach	9	35
Need to deal with a particular subject/topic	8	31
Failure of existing materials/approach	7	27
Through use of systematic ID process	6	23
Constraints of the situation	5	19

[1]Percentages total more than 100 because each response statement was coded separately.

Table 3

What Constraints Were Encountered?

	N	%[1]
Difficulties in specifying objectives/outcomes	9	35
Meaningfulness of approach to students	5	19
Problems with media/materials/approaches	5	19
Administrative/bureaucratic problems	3	12
Difficulties in selecting subject matter	3	12
None	3	12
Teacher/user resistance	2	8
Time constraints	2	8
Cost/resource problems	2	8
Other problems with ID procedures	2	8

[1]Percentages total more than 100 because each response statement was coded separately.

Table 4

When Were You Finished?

	N	%[1]	N/9[2]
When all objectives were dealt with	14	54	5
Not finished	11	42	2
Arbitrary stopping point	5	19	2

[1]Percentages total more than 100 because each response statement was coded separately.

[2]Distribution of those 9 respondents who had trouble specifying objectives (from line 1, Table 3).