The Empirical Basis of Designing Instruction

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ABSTRACT

This manuscript discusses results of a preliminary study regarding how experts design instruction. Alumni from a faculty of educational science and technology were asked how they would approach various design tasks. Results revealed some interesting characteristics of the design process in

practice. Results are discussed in relation to the empirical status of the development of design models and to adapting current models towards a practice-oriented process of designing instruction. This orientation involves both design content, practical design experience, and design procedures.

Standard instructional systems design (ISD) models include a number of design steps from assessing needs to evaluating performance (e.g., Romiszowski, 1981; Shiffman, 1985; Dick & Carey, 1989; Shrock, 1991; Leshin, Pollack & Reigeluth, 1992). In these models, many theoretical ideas and practical considerations from research and development literature have been integrated. Recent models differ from previous ones by their performance technology viewpoint: instruction is not always the solution. During needs assessment and needs analysis it will become evident what the problem is. On the basis of the results, the instructional designer in collaboration with the client will decide if an instructional solution or another solution will be designed (e.g., changes in job structure or in the organization of the work). The main focus of this type of instruc-

tional systems design is solving performance problems in organizations.

The main characteristic of the standard ISD models is solving instructional problems according to a general idea of problem solving: problem analysis and defining, and designing, developing, and implementing the solution. This prototypic model of solving problems agrees with the "General Problem Solver" of Newell and Simon (1972). Optimization of goal functions is a second important characteristic of models of instructional systems design. Both of these characteristics of a deterministic process for designing instruction have been questioned in recent years. Generic problem solving has been criticized by research on expert-novice differences and on context-bounded transfer of training (Perkins & Salomon, 1989). According to Merrill, Li & Jones (1991), first generation instructional systems de-

sign models lack methods for dealing with interdependent processes; they assume the user has essential skills for understanding complex and dynamic phenomena. These models also reveal limitations in prescriptive value. As closed systems, they fail to integrate instructional development, leading to passive instruction. Second generation models developed by Merrill c.s. are knowledge based and contain intelligent decision tools for analyzing problems and generating solutions, leading to adaptive instruction.

Despite its intuitive attractiveness, the second generation model still is deterministic in nature. The process of designing instruction is assumed to be logical and transparent, and is therefore apt to be automated. Recent research on how experts design instruction (Rowland, 1992; Korpi, Greeno & Jackson, 1991; Goel & Pirolli, 1992) provides evidence that experts differ from novice designers in approaching instructional problems. They rarely follow some specific pre-determined model, but instead design intuitively, reflectively, by considering alternative solutions in tandem. This article addresses the differences between how *experts* practice design and the theoretical start provided to novices.

The informal, unsystematic observations by and experience of designers, both novices (e.g., students) and experts (e.g., professors in instructional systems design and professional designers) reveal that designing instruction does not strictly follow the rules prescribed by the models of instructional systems design. The actual process of designing is far more complicated than models

suggest, and sometimes the process contains short-circuits. Some personal observations from our faculty are:

- Novices, intermediates, and experts report that no two uses of the design process are ever identical;
- No linear paths can be observed in the design process;
- Expert knowledge is not always an advantage; it sometimes even limits the number of solutions the designer is willing to consider (new and unexpected solutions may become less likely);
- Experts rapidly design a solution, often by immediately perceiving the solution from a vast knowledgebase;
- Potential solutions decrease the problem space, especially with expert designers; and
- Experts do not always reflect.

In his 1992 study, Rowland found:

- Iterative designing by experts;
- Knowledge-building cycles leading to problem-solving schemes;
- Opportunistic designing;
- Not delaying solution attempts (complete understanding is unattainable).

In the study presented here, we invited instructional designers to indicate how they would design solutions for instructional problems by applying a library of instructional design tools (i.e., a list of potentially relevant instructional design activities). The subjects' task was to list the tools that they thought were appropriate for designing a solution. The instructional designers were alumni from our faculty of Educa-

tional Sciences and Technology, all of whom were educated in the instructional systems design tradition.

From the start, our program of Educational Technology in Twente has used a socially-oriented, systems-design model as the standard model students are taught. They were expected first to analyze the problem, quite often a performance problem, and then to decide what the solution would be: instruction, or other performance interventions. Another important issue related to this model and severely stressed by professors in our program is the *feasibility* of implementing the solution. In

traditional models, implementation follows the construction of the solution. In our conception of instructional systems design, it is essential that designers realize in advance how open the intended users or other stakeholders are to a variety of potential solutions.

We had two main objectives. The first was to study the development of instructional systems design expertise. It appears expertise develops gradually as practitioners proceed along a continuum that begins with a general systems approach and evolves into a more intuitive ap-

proach that emphasizes prototyping as a solution path. How does this happen? The second objective involves inquiry into the empirical basis of the instructional systems design models themselves. Usually, these models have been validated only by expert appraisal and by practical experience. According to Wilson and Jonassen (1991), empirically de-

rived knowledge about the problem-solving heuristics of professional instructional systems designers is lacking. Questions like the following have to be asked: "What actions are to be taken by designers, related to

Designing and learning to design instruction imply a struggle to overcome not only persistent learning and transfer problems, but also managerial and interpersonal problems. Social and communicative variables play an important role in the process from proposal to approval, design, and development.

any instructional design model? What kind of prescriptions do they follow, if they use any? Or do they use intuition or professional expertise acquired by experience?"

Method

Subjects

Participants in our study were 120 alumni graduated at the Faculty of Educational Science and Technology of the University of Twente from 1985 to 1992 who are currently working in various branches of education and training.

Materials and Tasks

Participants were sent a letter in which the objectives of the study and the questionnaire were described. The questionnaire had four parts. Part I contained twenty-one open-ended and multiple-choice questions about the background and job characteristics of the respondent (e.g., number of years of relevant work experience, type and structure of the organization, number of employees, functions and tasks of the training and development department, and amount of work done individually vs. in teams).

Part II was comprised of descriptions of two hypothetical organizational problems, approximately 200 words each, indicating particular needs and conditions within the organizations. Appendix 1 contains a brief description of the two problems presented. The respondents were asked to select relevant instructional design activities from a list of 69 activities they would use to solve one of the problems. Respondents were allowed to apply only the instructional design activities from the list. The list of 69 activities was composed using the instructional methods and variables presented by several authors (Andrews & Goodson, 1980; Dick & Carey, 1989; Gropper, 1977; Zemke, 1985). The number and type of activities respondents selected in this part of the survey are shown in Table 1.

Part III contained an open-problem description in which respondents were asked to describe in about 100 words the elements of an instructional design problem that was typical for their own organization, and then to determine the main activities (from the list mentioned in Part II)

they would apply when solving that problem in their organization.

Part IV included open-ended questions concerning the way their organizations usually solved instructional design problems, about the instructional systems design model(s) used within their organizations, and about the elements of their "personal model" compared to the general model that is used within the Faculty of Educational Science and Technology.

Results

Thirty-five out of 120 questionnaires were returned. A number of alumni who did not return their questionnaires indicated they had changed jobs or functions and were no longer involved in instructional systems design and development. Of the 35 questionnaires returned, not everyone was able to completely fill in all four parts of the questionnaire.

The data indicates most respondents had two to six years of professional experience. Over 50% work in private, for-profit organizations; 30% work in publicly financed organizations; 90% work in the service and health care arenas (e.g., trade, banking, hospitals, and schools). In 75% of the organizations there is no separate training and development department. They work in small and medium-sized organizations (10-250 employees). They organize their work in collaboration with colleagues—design activities are a kind of collaborative work. Two-thirds of the respondents are committed to every instructional design activity undertaken by their organization.

The survey asked respondents to compare their (and their organizations') instructional design approaches with the model presented

Table 1
Average Number of Activities Chosen in Each Design Phase for Low- and High-Experience Groups (Part II)

Design Phases	Low Experience 1 - 3 years N = 11	High Experience > 3 years N = 15
Analysis	5.27	6.87
Design	3.64	6.80
Development	2.27	3.33
Evaluation	1.27	3.20
Implementation	1.00	1.80
Management	2.36	3.13

Note. The figures in this table indicate the number of activities reported in each design phase divided by the number of respondents.

by the Faculty of Educational Science and Technology of the University of Twente, using the labels: "No difference," "more phases," "fewer phases," "different order of phases," and "other differences," annotating their responses as necessary. The results (note that only 30 respondents answered this question) clearly show that some years after leaving the university, alumni implicitly modify their way of working. Six respondents reported no differences between their own model and the faculty model. Five respondents reported that, depending on the kind of work and the domain in which they are working, there are a number of activities they employ that were not in the model they were taught (e.g., adoption phase before needs analysis, micro-design and prototype design are separated, regular feedback to management and other clients, design phase is separated into

macro-, meso- and micro-design levels, marketing activities, and more communication with client). Ten respondents use fewer activities due to constraints in organizational culture (more attention is paid to implementation and participatory designing) and in expenditures (no prototype design). In the category of fewer phases, the following elements are mentioned: no clear differences between phases, more attention to organizational implementation, constrained needs analysis, constrained implementation, no prototype design, restricted evaluation, many steps/activities made implicitly, prototype design not feasible, and "outside development."

It is interesting to note, under the category of difference heading "order of phases," four respondents describe design as not just following some pre-planned phases, but instead, as an activity that is heavily context de-

Table 2
Average Number of Activities Chosen by Work Experience and Design Phases (Part III)

Design Phases	Low Experience 1 - 3 years N = 11	High Experience > 3 years N = 15
Analysis	5.00	5.86
Design	5.20	8.14
Development	1.60	2.29
Evaluation	1.20	3.43
Implementation	1.60	1.29
Management	1.80	3.00

Note. The figures in this table indicate the number of activities reported divided by the number of respondents.

pendent and integrated. In their view, designing does not always *follow* analysis, and "leaving" one phase may result in a return to that phase. Five respondents claim it is not the designer but the client who determines the content and the order of the phases. Other differences mentioned by these five respondents: Due to less time, designing is more integrated, there is sometimes no implementation, implementation is carried out by the designer and design is often tacit (i.e., done without knowledge that a systematic procedure is being followed).

Table 1 shows the work experience of the respondents and the average number of activities chosen per design phase in Part 11, the two hypothetical cases. Less experienced respondents mentioned fewer activities than their more experienced colleagues. Not only the number of activities chosen by the less-experi-

enced and more-experienced designers differs, the dispersion of activities among the seven phases also differs. The greatest difference for less experienced and more experienced respondents is in the number of activities related to the Design and Evaluation phases.

We also asked the respondents to indicate the assignments or problems they are regularly confronted with in their occupational environment and to further indicate which activities they would choose if they were asked to solve those particular training problems. The number of activities chosen in Table 2 is again related to the number of respondents who chose that assignment and their work experience. A trend that can be observed in the Table 1 is more obvious in Table 2. Here too, the Design and the Evaluation phases show a remarkable difference between the respondent groups, especially in the

Table 3
Work Experience and Design Activities Chosen
for Cases in Survey Part II

	Work Experience	
	1 - 3 years N=11	> 3 years N=15
Syrup Ltd.	N = 8 Specify Budget Conduct Needs Assessment Conduct task Analysis Specify Conditions Contact with Clients Design Instructional Materials Specify Course Content Specify Instructional Plan Use of Feedback	N = 12 Define the Problem Specify Target Group Specify Budget Specify Conditions Choosing the Solution
Electronic Mail	N = 3 Specify Budget Specify Conditions Consult Relevant Sources Contact with Clients Weight Alternatives Choosing the Solution Formulate Goals Specify Course Content Specify Instructional Plan	N = 3 Analyze the Problem Specify Target Group Conduct Needs Analysis Generate Ideas
Note. This table lists activities reported by all respondents in each category.		

area of course design. Because of the few number of respondents per cell, it is hard to draw any conclusions from the data displayed in this table. Only for course design can the results be compared. For the other activities mentioned by the respondents, the figures have to be considered unstable due to the small numbers of responses.

Table 3 is directed to the specific nature of the activities chosen by the respondents. The more experienced respondents choose the problem defining and analyzing activities, whereas the less experienced ones choose activities involving contact with clients. Due to the conditions and context mentioned above, these designers do not always design in the

way they were trained but often utilize design knowledge acquired through experience.

Conclusions

The group of thirty-five respondents is obviously not representative of the entire population of alumni of the Department of Education nor is it representative of instructional designers in general. We did not intend to gather information to generalize to the entire population. It was our intention to gather information about the progress of instructional design expertise of a group of instructional designers educated with the same general model of instructional systems design. We were especially interested in the difference between the practice and evolution of ISD in contrast to the theoretical models taught.

Results indicate most respondents have between two and six years of experience. They are mainly working in private, for-profit organizations, primarily within the service and health sectors in relatively small enterprises (5-49 employees). The structure is professional/divisional with few separate training and development departments. The kind of ISD problem descriptions the respondents are working with are a mixture of internal and external problems, although quite a number of the respondents work for external clients. The respondents are involved in a mixture of individual and group work, dependent on the projects to be performed. This also accounts for differences in the type of participation indicated (full participation in all instructional design activities vs. partial or specialized participation in other organizations).

Quite a number of respondents are involved in every instructional design activity within their organization. A division of labour can be discerned for only a few respondents.

Although all the respondents were educated in the general model of instructional systems design applied within the Faculty of Educational Science and Technology, a great many of them admit that deviations and discrepancies do occur. These discrepancies relate to the practical context of working (e.g., working in a context in which one has to achieve under high time pressure). A number of the respondents remark that, due to these conditions, prototype design and evaluation are devoted less time than strictly needed. Another important remark concerns the order in which activities have to be performed. Responses indicate integrated design with fluid boundaries between phases and activities within phases. They also indicate that previous activities are frequently revisited as kind of iterative process is followed.

These remarks, expressed by the respondents in comments adjacent to the lists they filled in, are presented in Table 3. The more experienced respondents tend to emphasize problem defining and analyzing activities, whereas the less experienced ones tend to choose activities involving contact with clients.

Implications for Instructional Systems Design

What may the results of this study imply for the model we formulated for our faculty, for training our students, and for the application of ISD

models in general? First, we still believe it is worthwhile to start with a systematic approach to training our students. This approach will present them a structured overview of the design process they are not familiar with. As soon as designers acquire practical knowledge concerning the application of the model (e.g., through assignments and internships), deviations and discrepancies may occur, and flexibility will grow.

This is, in our opinion, the way expertise will be acquired, from a structured generic approach for solving problems to a more flexible,

schema-based approach. As Schmidt et al. (1990) asserted for the medical domain: expertise is not so much a matter of superior reasoning skills or in-depth knowledge of a domain at hand. The expert's cognitive structure contains a wealth of professionally relevant information about, for instance—disease, its consequences, and the context under which illness develops. This conception of the function of contextual knowledge in expert behaviour is the core of Schmid, Norman & Boshuizen's (1990) theory of the development of expertise in medicine. Although this theory is confined to the development of expertise in the medical domain, it may well transfer to the design domain. Schmidt et al. (1990) distinguish four stages. In their terminology, these can be described as: 1) Development

of Elaborated Causal Networks, 2) Compilation of Elaborated Networks into Abridged Ones, 3) Emergence of Illness Scripts, and 4) Storing Patient Encounters as Instance Scripts.

Schmidt et al. assert that expert clinicians rapidly recognize a new disease on the basis of previously encountered ones. This implies that an expert must have many instances at direct disposal, something that at first sight appears to exceed the limits

of memory processes. There is evidence, however, from studies within other domains (e.g., Chi, Glaser & Farr, 1988) that such a

A combination of a systematic approach and a relational approach seems to be very fruitful, especially for arriving at internal and external curriculum consistency.

remarkable performance by experts is indeed possible. Expert designers appear to be similar in their design processes. In the statements made by some of the alumni, the expertise at Level 3 of Schmidt et al. is well expressed. On this level, intermediates may reach to a contextual stadium, that is they will gain expertise in recognizing the contextual characteristics of the clinical appearance of a disease. The relevant signs and symptoms together with the presentation of a patient problem will trigger mental representations with a list-like structure. This representation is called an 'illness script'. Assessing different patient problems, in this stage, gradually leads to a compilation of the knowledge from the causal network representation into diagnostic labels, and, concur-

rently, to a contextualized nature of these labels. This is also in line with the evidence cited by Rowland (1992). Experts can decrease their problem space by immediately recognizing alternative solutions. For students to fill their systematic approach with declarative and contextual knowledge, to become experts, a lot of cases must be presented. If these cases are different from each other, the contextual knowledge necessary to become a flexible designer can be acquired.

Second, several alumni expressed that social and communicative variables play an important role in the process from proposal, to approval, design, and development. A socially oriented approach will emphasize the process necessary to reach a solution that can be accepted by every participant, from client to trainee. Recently, Kessels (1993) published results of a study in which a combination of a systematic approach and a relational approach was applied in the design process. This combination seems to be very fruitful, especially for arriving at internal and external curriculum consistency. Internal consistency can be achieved by applying a systematic approach for designing instructional systems, including needs assessment, task analysis, prototype design, evaluation, and implementation. External curriculum consistency can be achieved using a relational approach, aiming at creating a positive and supportive climate in which all participants can cooperate effectively.

Third, it is surprising that evaluation and implementation activities did not receive the amount of time and attention they deserve. Time for

applying a test of the solution is often short. Also, less concern is devoted to implementation, in particular by the more experienced designers. This regards the core of the relational approach by Kessels (1993). His approach refers to activities of designers involved in interpersonal dynamics in designing corporate education. These dynamics are very pertinent in project management, in involvement of higher and middle management in needs assessment and task analysis, in promoting transfer of training, and in creating a comfortable and supportive climate for design.

In conclusion, designing and learning to design instruction imply a struggle to overcome not only persistent learning and transfer problems, but also managerial and interpersonal problems. Traditional models for instructional design strongly emphasize systematic design based on rigorous application of scientific and practical knowledge. This process is often carried out by a designer on his or her own. Future models not only have to incorporate an analysis of the social system in which the proposed solution will be implemented, but also an analysis of the acting expertise involved in the process of designing. Learning experts, media experts, subject matter experts, implementation experts, and evaluation experts will have to learn to cooperate in a systematic fashion to ensure the optimization of the solution. Before going into the process of designing, an expertise analysis should be performed to enable project staff to hire the right expertise for doing specific design jobs. An additional analysis will reveal the proposed interaction pattern between design partners. It is obvious

that the pace of analyzing and designing is not the same for every participant. Some need more information to analyze than others. This offers new opportunities to install collaborative prototyping: a (partial) solution of one expert may constrain the problem space for the other expert. This highly interactive and collaborative process of designing thus becomes a very effective way of collecting the expertise and knowledge to be integrated in a converging artifact.

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Appendix A.

Brief Descriptions of the Cases Presented to Respondents

Case 1 Syrup Ltd.

Syrup Ltd., a soda company, is very famous all over the country and shares a high percentage of the market. Due to an increased demand for soda in the past two years, Syrup was not able to supply the products in a sufficient way. Large numbers of employees were forced to work on Saturdays. To increase production capacity, a number of new employees are hired. As usual within Syrup, the training of the new people is something that happens 'on the work floor, next to Nellie' (i.e., there is no systematic and well documented policy for training new employees). But the number of new people needed makes it impossible to train them in the old-fashioned way. You, as a training consultant, are asked to solve this problem.

The conditions are:

- The new employees have limited education.
- The new group of employees is very heterogeneous with respect to work experience.
- There are no opportunities to do the training outside the company. It has to happen on the work floor.

Case 2 Electronic Mail

In your organization a need is felt for a course on using and maintaining an electronic mail system. The need was expressed by the department responsible for marketing and direct mailing to quite a number of clients. The letters sent to the clients all have an identical format and similar content. Such a system calls for standardization.

Training is not an explicit issue within the organization. New employees are introduced by experienced colleagues who tell and demonstrate what to do. This is a time-consuming activity for both the experienced colleague and the new employee. Another disadvantage is that misconceptions and errors are also transferred to the new employee. Your task is to design a course that upgrades the expertise of the employees and offer them the required knowledge and skill.