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**ABSTRACT**

Ten individuals in the Educational Technology Program at the University of Northern Colorado served as subjects for this study, which was designed to: (1) identify cognitive networks of concepts within components of a system design model for expert and novice instructional developers, and (2) determine cognitive networks of concepts between components of the model for both groups in order to examine the structure of 13 concept interactions for the instructional development process. Structures for both groups were analyzed according to median distances within and between concepts describing the analysis, design, and evaluation components of a learning system design model. Results were interpreted for distance and dispersion of experts' and novices' concept organization by determining the mean of the medians for each group and the standard deviations of the means. Findings showed experts' organization of concepts within the three components of the model to be more consistent with accepted structure of the instructional development process, and novices' structures to be more linear and less integrative in reference to the model. These results provide a framework for the theoretical interpretation of constructs underlying successful performance in instructional development. Such information can be used to guide selection, training, and assessment research of instructional developers. Attachments to this paper include a 19-item reference list, one figure, and five tables. (DJR)

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**Cognitive Structure Organization:  
A Theoretical View of the Instructional Development Process**

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## Abstract

Cognitive structures for expert and novice developers were identified through thirteen concepts representing the instructional development process. Structures for both groups were analyzed according to median (to control for skewed distributions) distances within and between concepts describing the Analysis, Design and Evaluation components of a learning system design model (Davis, Alexander, & Yelon, 1974). For each analysis, results were interpreted for distance and dispersion of experts' and novices' concept organization by determining the mean (generally considered the most stable measure of central tendency) of the medians and standard deviations. Consistent with theory, (Geeslin & Shavelson, 1975; Chi, Feltovich, & Glaser, 1981) findings showed experts' organization of concepts within the three components of the model to be more consistent with accepted structure of the instructional development process. Further analyses of concept organization among the Analysis, Design and Evaluation components showed novices' structures to be more linear and less integrative in reference to the model. Outcomes of this study provide a framework to ~~theoretically interpret constructs which underlie successful~~ performance in instructional development. Such information can be used to guide selection, training and assessment research of instructional developers.

Past efforts to assess instructional developers have indicated that an empirical framework of the instructional development process is needed (Faris, 1981; Maxwell & Seyfer, 1984; Bratton, 1984). Within instructional analysis approaches, both correlational and causal assumptions have been hypothesized regarding the relationship between cognitive structure and behavior (Rae, 1986). First, knowledge of individuals' cognitive structures may make it possible to predict behavior. Second, it may be possible to modify these structures (and thus, the behavior itself) by some form of training. However, these hypotheses have not been systematically tested.

Procedures used in effective instructional development involve a synthesis of information relevant to the task with a repertoire of proficient problem-solving strategies (Wagner, 1986). Likewise, Jeffries, Turner, Polson, & Atwood (1981) have suggested that skilled developers (1) have knowledge about the global structure of good development and (2) plan their performance according to structural constraints within the learning system. From an information processing view, it would be expected that an individual's organization of instructional development concepts in memory influences how one perceives, attends to, processes and ultimately, solves tasks within the discipline.

In contrast to behaviorist or associationist theories of learning, the cognitive approach postulates that relevant aspects of a pre-existing memory structure interact with new knowledge to

result in active, meaningful learning. Students who acquire concepts early in instruction consolidate more of the learning and achieve greater success in problem-solving (Shavelson, 1973). In fact, it has been suggested that the most significant independent factor influencing capacity for acquisition of additional knowledge in a discipline is formation of a clear, stable, and well organized cognitive structure (Ausubel, Novak, & Hanesian, 1968). Shavelson (1972) also found that, as students gain new knowledge, their cognitive structures begin to resemble relationship hierarchies similar to experts. Through identification of individuals' cognitive maps, organization of conceptual knowledge may be better understood in terms of how these networks represent level of expertise.

Within the past twenty years, research in mathematics and science has provided information about the influence of cognitive structure organization and procedural knowledge strategies on problem-solving performance (Ausubel, et al., 1968; Wittrock, 1974; Geeslin & Shavelson, 1975; Greeno, 1978; Gorodetsky & Hoz, 1980; Chi, Feltovich, & Glaser, 1981). These studies have shown that ~~knowledge structures of experts and novices differ in domain-~~ specific organization and that these differences enable experts to solve such problems more effectively. Since instructional development is essentially applied cognition in problem-solving (Wagner, 1986), there is a need for research that can illuminate how cognitive structures between experts and novices are organized.

This information can be used to further examine knowledge compilation (procedural performance) and ways in which developers represent and transfer knowledge, and evaluate tasks when solving development problems.

Ultimately, it is knowledge organization and procedures activated from this store that determine the quality of problem-solving (Gagne, 1985). Problem-solving is often the most common way of testing whether individuals meaningfully comprehend the ideas they verbalize. However, present assessment techniques to determine competent developer performance disregard knowledge investigation in favor of performance analysis which lacks empirical validation. This course of action is somewhat premature and certainly incapable of rational defense. Before measurement of performance can be accurately conducted, it is necessary to systematically identify the theoretical constructs that underlie successful performance in instructional development.

Therefore, the purposes of this research were to 1) identify cognitive networks of concepts within components of a system design model (Davis, Alexander, & Yelon, 1974) for expert and novice instructional developers, and 2) determine cognitive networks of concepts between components of the model for both groups in order to examine the structure of concept interactions for the instructional development process.

Based on information-processing and assimilation theories, (Anderson & Bower, 1973; Ausubel, et al., 1968), inquiry was

directed according to the philosophy that relevant, pre-existing concepts in memory vary in organization between expert and novice instructional developers. Given knowledge of these structures, it is possible to assess how an individual represents and, in turn, operationalizes the instructional development process. First, variables that represent the development process were specified according to a learning system design model (Davis, Alexander, & Yelon, 1974). This model was used because it has been accepted in practice, as one way to represent basic steps of the instructional development process. Since there is a vast array of information relevant to the discipline, only the most general, inclusive concepts were used to provide anchorage in a wide variety of instructional development situations. Next, it was determined how these concepts are related in the cognitive structures of expert and novice instructional developers. Although individuals' networks are unique, earlier research has found experts' knowledge organization to be more consistent with the accepted structure of a subject matter (Geeslin & Shavelson, 1975; Chi, Feltovich, & Glaser, 1981).

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## Materials

Thirteen concepts were selected according to the system design model (Davis, Alexander, & Yelon, 1974) to represent the development process:

### Analysis Component

- Performance Objectives (PO)
- Learner/Trainee Characteristics (LTCH)
- Task Analysis (TA)
- Needs Analysis (NA)
- Learner/Trainee Prerequisites (LTP)
- Learning/Training Environment (LTE)

### Design Component

- Instructional/Training Strategies (ITS)
- Learning/Training Course (LTCO)
- Course Design (CD)

### Evaluation Component

- Pilot Study (PS)
  - Learning/Training Outcomes (LTO)
  - Evaluation (E)
  - ~~Course Revision (CR)~~
- 

Three random arrangements of concepts were prepared to control for possible sequence effects.

## Subjects

Ten individuals (5 experts, 5 novices) in the Educational Technology Program at the University of Northern Colorado were



chosen on the basis of formal instruction within the discipline. The expert group included three faculty members and two doctoral candidates (3 males, 2 females). The novice group included four doctoral students and one master's student (3 males, 2 females).

### Procedure

A graphic data analysis procedure (Preece, 1976) was used to determine subjects' cognitive structures for the instructional development process. Individuals were randomly given one of the three equivalent concept lists with instructions. Prior to the mapping exercise, subjects were verbally screened to insure that they were familiar with the concepts. The mapping activity required subjects to look through the list of concepts and initially choose the two concepts they believed to be most closely connected.

Individuals crossed these concepts off the list, wrote them down on a blank sheet of paper, and connected them with a line labeled as "#1". Subjects were then required to examine the remaining concepts and choose another concept which they perceived to be the next most related to one of the concepts already chosen, or in some instances, to another concept on the list. In either case, the same procedure was followed to connect concepts. Individuals continued in this

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manner until all the concepts were joined to at least one other concept from the list. Since subjects were individually tested, they were not permitted to begin the activity until the examiner determined that they properly understood the instructions.

## Results

Figure 1 gives the system design model according to the thirteen concepts used to describe the process (based on Davis, Alexander, & Yelon, 1974, p. 19).

Cognitive maps were scored by counting the number of connections (distance) between concepts. Median distances (to control for skewed distributions) were computed for all pairwise combinations of concepts within and between the Analysis, Design, and Evaluation components of the model for both groups. Then, the mean (generally considered the most stable measure of central tendency) of the medians for each group was calculated to represent the average distance of the within and between concepts. Standard deviations of the means were used to gauge variability of individuals' structures within their respective group.

The first concern of this study was to identify conceptual networks of the instructional development process within the Analysis, Design, and Evaluation components of the system design model for both experts and novices. Table 2 shows that the mean distance and dispersion of scores within the Analysis concepts was 2.47 (SD = .92) for experts and 2.73 (SD = .96) for novices. The smaller distance for the expert group suggests a more integrated cognitive structure. Table 3 shows distances and variability of scores within the Design concepts for both groups. Again, experts' mean distance and lower standard deviation (2.00, SD = 1.00), compared to novices' (2.67, SD = 1.15), signifies that the expert

group similarly organized Design concepts to be more compatible with the structure of the model shown in Figure 1. Table 4 shows that while experts, once more, showed less distance (2.17) than novices (2.33), the spread of scores within each group was quite different. Experts' lower standard deviation (.75) indicates that their structures for Evaluation concepts were more consistent. On the other hand, the novice group showed a much higher variability (SD = 1.37) and thus, less agreement in their organization of Evaluation concepts.

The second concern of this study was to determine cognitive structures for concepts between components of the model in order to examine the structure of concept interactions throughout the instructional development process for both groups. The same procedure was used to determine medians, the mean distance of the medians and spread of scores. These analyses revealed that different patterns emerged when concepts between components were compared.

Table 5 shows that the mean distance between Analysis and Design concepts for experts' (3.50) was greater than novices (2.39). However, individual differences within groups showed little variability: experts (SD = .86) vs. novices (SD = .92). Table 6 reveals that experts' structure and spread of scores (3.33, SD = 1.37) was more dispersed than novices' (3.08, SD = 1.08) for Design and Evaluation concepts. And, results given in Table 7 indicate that organization of Analysis and Evaluation concepts is

similar for experts (4.46) and novices (4.58). However, experts were less consistent with each other ( $SD = 1.56$ ) than were novices ( $SD = 1.14$ ).

Although cognitive structure research is primarily descriptive in nature, the means and standard deviations generated from this descriptive study provided a basis for statistical inferences. As expected, preliminary T-tests for differences in means and F-tests among variances suggested that the small sample size ( $N = 10$ ) did not permit a level of power necessary to detect significant differences. Further analyses were conducted to explore this speculation. When the sample size was estimated at  $N = 20$ , results showed differences to be significant at the .05 level.

### Discussion

Concept distances, both within and between components of a learning system design model, were computed according to median values for pairwise combinations. Average distances for each analysis were determined using the mean of the median for each group. And, standard deviations were used to examine the spread of scores.

In the first part of the study, results showed that within each component, experts demonstrated a more succinct conceptual network. These findings are in accordance with the theoretical position that experts' knowledge organization is more consistent with the accepted structure of a discipline (Geeslin & Shavelson, 1975; Chi, Feltovich, & Glaser, 1981).

In the second concern of the study, concept distances between components of the model appeared to be consistent with accepted principles of instructional development. Results coincided with the "systems approach" philosophy which postulates that in all phases of the development process, the developer must acknowledge that system components are interdependent and dynamically influence each other (Davis, Alexander, & Yelon, 1974). This implies a non-linear process in which elements within the system interact throughout the entire course of development. Thus, it should be expected that the expert developers would consider interactions among concepts and consequently display greater distances in their structures for Analysis-Design and Design-Evaluation comparisons. Conversely, it should apply that a novice approach towards development is more linear and therefore, distances between concepts would be smaller in Analysis-Design and Design-Evaluation comparisons. Results of the final contrast, Analysis-Evaluation, were also explainable. According to heuristics of instructional development (Davis, Alexander, & Yelon, 1974), planning for evaluation should originate in the Analysis stage. Thus, it would be expected that concept distances for both groups should be somewhat similar.

The findings of this descriptive study provide information needed to empirically identify and interpret the theoretical constructs that underlie successful performance in instructional development. These preliminary results suggest that experts and novices differ in their conceptual organization, both within and

between components of instructional development process. According to theory (Chi, Feltovich, & Glaser, 1981), these differences should enable experts to solve instructional development tasks more effectively.

The study should be replicated with a larger number and more diverse group of instructional developers to further define distinctions found in this research and better facilitate inferential analyses. Future studies also need to investigate (1) if there are significant differences in concept organization among individuals within their respective groups (2) how the direction of concept organization in cognitive structure relates to accepted instructional development procedures, and (3) how conceptual organization of the instructional development process relates to performance. Answers to such questions can provide a link between theory and practice. Educators and practitioners need this integration to devise rational, defensible, and empirically-validated procedures for selection, training and assessment of instructional developers.

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**FIGURE**

**and**

**TABLES**



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# CONCEPT D

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# CONCEPT DISTANCES

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# CONCEPT DISTANCE

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# CONCEPT DISTANCE

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