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ABSTRACT

This paper offers a pragmatic critique of the instructional prescriptions based on Structural Learning Theory (SLT) conceived by Joseph M. Scandura in 1973. SLT is rooted in clarifying the roles of expository and discovery modes of problem solving in instruction. It is a cognitively oriented model combining learning theories, instructional theories, and instructional-development procedures. SLT proposes that content should be taught in the form of rules, on the most macro level possible. It proposes use of equivalence with mastery of any rule in a group taken as mastery of all rules within that group. In designing instruction, SLT requires the use of educational goals as initial inputs, determination of prototypic cognitive processes to measure learning, and structural analysis to determine content. SLT has been applied in artificial intelligence and computer-assisted instruction and related areas. SLT helps learners develop their own background knowledge and encourages learner processing. SLT has a wide range of applicability and provides a process for the selection of lessons or topics from a body of knowledge as well as a method for optimal presentation of the instruction. (Contains 26 references.) (JLS)

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SCANDURA'S STRUCTURAL LEARNING THEORY: A CRITIQUE

by

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Abstract

How could the results of several years of research endeavors and practice in the field of Instructional Systems and Technology influence the application of Scandura's structural learning theory? In what ways are the differences and/or similarities of these research efforts and field experiences fit together? Research findings allow us to articulate a major goal of education: `helping students develop well-organized knowledge structures,' and integrate these findings into our teaching practice to effect knowledge gains and transfer.

This article offers a pragmatic critique of the instructional prescriptions based on Scandura's Structural Learning Theory (SLT). It also details the merits and demerits of SLT as they relate to the fields of Instructional Systems and Educational Technology as well as implications for instructional designers.

Structural learning theory enables the instructor to quickly and accurately select a content and sequencing requirements for teaching the contents' rules. Sequencing of the instructional material is an added advantage for SLT. Because of this sequencing technique, testing is needed for only a segmented part of the rule(s), and mastery at the macro level is indicative of mastery at the micro level of that rule. In well-developed structures, synergism is the key -- the parts are well organized, the pieces are well connected, and the links between the connections are strong.

In psychometry and Educational Technology, the application of SLT makes it possible to formulate other cognitively oriented instructional theories. Cognitive Theory of Inquiry Teaching is an

extension of SLT and item difficulties and analyses are accurately diagnosed in lesson plans based on SLT. Moreover, SLT grants the learners the added advantage to form their own schema (or schemata as in discovery learning.

It is quite appalling that Scandura's theory did not make it past 1988. Literature about this theory actually stopped in 1985 after Scandura's second phase of SLT. It seems somewhat that the theory has been forgotten, not refined, and totally discarded. Therefore, the structural learning theory has no influence and applications in school settings, and as such not cumulative. Also, in as much as SLT deals with audience analyses, it did not include the background knowledge of this audience in either its original or revised versions.

STRUCTURAL LEARNING THEORY: A CRITIQUE

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0.0 Preface

An instructional theory addresses three questions: what methods should be used in the instructional systems design?, the situation where each of these methods will be used? (that is, the basis for prescribing the instructional method), and what type of principles will link these methods to a particular situation. Structural learning theory is an instructional theory about what happens inside the learners during instruction and learning. It assumes that learners organize their thinking about the world in form of rules and rule structures, and is about the way learners acquire, use, and modify their existing knowledge.

In this critique of the Structural Learning Theory (SLT), I would like to discuss what I regard as some of the most important aspects of the theory, including its instructional specifications as they relate to the learners, its wide areas of applicability, research on teacher effectiveness with regard to the micro and macro rules, and the pragmatic importance of the theory in the field of instructional systems and technology. Attention will then be focused on the practical and research implications of SLT in terms of the advantages and disadvantages of the structural learning theory.

1.0 Scandura's Structural Learning Theory

Since an instructional theory MUST be prescriptive to the extent that it must be able to control or influence learning, Scandura's SLT is both a theory of instruction and learning. On the other hand, descriptive theories are relevant for explanatory purposes, therefore, SLT is not a descriptive theory. SLT is not a taxonomic theory of instruction because such taxonomic theories of instruction are designed to meet immediate taxonomic practical ends. It is an individualized prescriptive theory of instruction that can also be used for a group if the situation warrants. Moreover, SLT provides a general method of analysis by which rules (principles or regularity conditions) to be learned can be derived from suitably operationalized educational goal(s). It is a unifying theoretical framework within which the interactive roles of teaching-learning processes can be evaluated and it bridges the gap between MEDIOCRITY and EXPERT. It is not a scientific language. It is, however, a language about human learning behaviors and how their quest for knowledge are satisfied. It can also be applied to instruction for learners with no skills or previous experiences, learners with some competence of the solution rules, or learners with advanced skills and knowledge base in the subject matter.

1.1 Definition of the Theory:

Structural Learning Theory (SLT) is a prescriptive theory of instruction that was initially conceived and developed as a learning theory by Joseph M. Scandura in 1973. The motivation for SLT stemmed from instructional considerations in both the classroom and non-school settings. The objective of SLT was rooted in clarifying the roles of expository and discovery modes of problem solving in instruction (Scandura, 1964). Simply stated, structural learning theory is a cognitively oriented model that combines the learning theories, instructional theories, and instructional-development procedures in algorithmic formats for an individual or a group of individuals.

1.2 Contributions of the Theory:

Listed below are some of the contributions of structural learning theory (Scandura, 1983):-

(a) Selection of Content: Scandura theorized that all content should be taught in the form of rules, and that macro rules should be used in place of micro rules whenever possible.

(b) Equivalence classes: Structural learning theory provides a unique way of controlling, operationalizing, and identifying the categories of divergence. Mastery of any equivalence class for each rule is an indication of mastery of all the rules within that class. Therefore, testing learners' ability at various levels of the instructional plan is not necessary. Hence, test-retest is a form of instructional evaluation as well as a suggestive guide to revise the instructional strategy, lesson, goal, or content.

(c) Sequencing/Algorithms: Instructors who are using this theory should teach the simplest (micro rules) unmastered paths through a particular rule first, and then proceed to teach progressively those complex (macro rules) until the entire rule has been mastered.

1.3 Essentials of the Structural learning Theory:

To use the structural learning theory in designing instruction, the following essential requirements must be satisfied:-

(a) Educational Goals: These are what learners should be able to do after instruction. These are INPUTS in SLT (contrary to other taxonomic theories where they serve as outputs). In SLT jargon, these educational goals are equivalent to BEHAVIORAL OBJECTIVES; they are "WHAT MUST BE LEARNED."

(b) Prototypic Cognitive Processes: These are ACTIONS OR CONDITIONS on (or about) the educational goals. They relate to "HOW" the learners would perform the tasks which are associated with the educational goals. Prototypic cognitive processes are those THINGS the learner(s) MUST know (as determined by the instructor or instructional specification) in order to perform the task as expected.

(c) Structural Analysis: This is the general method of analysis in structural learning theory. It consists the following two steps:-

(i) Select a representative sample of problems associated with the educational goal. This may be content or domain-specific.

(ii) Identify rules for solving each of the selected problems.

Hence, in structural learning theory, what must be learned are the rules, the goals (stated as behavioral objectives - THE

PROBLEMS). These rules may be both content and domain specific. In problem domain, problems are formally characterized in terms of finite set of elements, relations, and operations defined on the elements and higher-order relations and operations. These operations and relations need not be defined on the same domains and ranges. The domain of the problem encompasses anything from arithmetic to language and moral behavior (Scandura, 1962. 1983). It can, however, be narrowed to suit the instructional objective. Content is the effective characterization of the tasks or problem situation that the instructor wants the students to master.

RULES: These are the necessary and sufficient conditions, the regularity conditions, or the underlying principles of the instructional process. They are the logical sequence(s) by which the solution(s) of the problem(s) is (are) derived. Rules are the theoretical constructs which may be used to represent all human epistemologies.

In structural learning theory, these rules do not operate on observable inputs but rather on unobservable cognitive structures of the inputs. By the same token, the rules do not generate observable outputs. They generate internal structures that represent these outputs. Each rule consists of:-

DOMAIN: These are the internal cognitive structures that correspond to the accumulated relevant environmental factors of a learning situation. Domain in SLT jargon is a set of encoded inputs to which the rule applies. That is, a set of conditions that each rule must satisfy.

RANGE: Is a set of undecoded outputs that the rules are expected to generate. That is, a set of anticipatory conditions characteristic of the outputs that the learner expects the rules to produce.

PROCEDURE/OPERATIONS (ALGORITHM): These are the steps, algorithms, or sequences of "unfolding events" that apply to all elements in the domain to generate the desired outputs. Rules also involve making some assumptions about the target audience:-

- Assumptions about the minimal encoding and decoding capabilities of the learners. These is the "Needs Assessment" or determination of the prerequisites of the learners.
- Assumptions about the scope of each of the representative prototype problem. These are the assumptions about the "INSTRUCTIONAL CONTENT" - the superordinates/corerequisites.
- Assumptions about and identification of the operational sequences in solving each prototypic problem within the content domain. Rules may also be broken into their ATOMIC and/or MOLECULAR components with distinct paths:-

ATOMIC RULES: These are steps/sequences that all members of the target audience are assumed to have (or not have) competencies in. These are the "MICRO RULES."

MOLECULAR RULES: A combination of two or more atomic rules is a molecular rule. Molecular rules are the "MACRO RULES." The link from atomic to atomic, atomic to molecular, or molecular to molecular rules is the "PATH." The paths partition the entire domain into distinct, exhaustive, and homogeneous "EQUIVALENCE CLASSES" or minimum rational sets; and mastery of each equivalence class within a path indicates mastery of all the equivalence classes in that path. Whence, success on any PATH of a rule depends on success in all atomic (molecular) components of each path

HIGHER-ORDER RULES: These are essential in structural learning theory because they:-

(a) ***OPERATE ON DATA STRUCTURES THAT CONTAIN RULES***

Generally, outputs are associated with given inputs. Higher-order rules are the macro rules in structural learning theory. They are the processes by which lower-order rules, associated with any number of different hierarchies are combined to form complex rules. Typical of these are the sub-routines in FORTRAN or PASCAL program that are incorporated into the main program.

(b) ***INCORPORATE RULE OF COMPETENCE***

These are the protocols, sequences or steps (i.e. - ALGORITHMS) the learners/students undergo in order to master the instructional content within the domain of knowledge.

(c) ***ENHANCE STRUCTURAL ANALYSIS PROCEDURES***

These are primarily "HOW TO IDENTIFY THE RULES OF COMPETENCE" underlying a given problem domain. structural analysis involves:-

- Specification of the problem domain;
- Specification of the rules needed to solve this problem; and
- Description of and existence of domain(s) of applicability.

It is, however, difficult to determine the domain's applicability in some problems. This is one of the areas that structural learning theory fails to be a domain-free theory as espoused by Scandura (Scandura, 1964, 1971, 1983).

1.4 Application of SLT in the Field of Instructional Systems Technology

The psychological basis for instructional design adopts the basic design specifications from:

(a) learning theories - behaviorism (Skinner, Watson, Keller, etc.) and cognitivism (Piaget, Sternberg, Ausubel, etc.); and

(b) instructional theories - behaviorism (Keller, Bandura, Wiener, etc.) and cognitivism (Gagne', Scandura, Landa, Reigeluth, Merrill, etc.).

The implication for instructional design relative to these learning and instructional theories is the link between the two theories and the research efforts in the field of Instructional Systems Design/Technology (ISD/IST).

A basic ISD/IST process starts from analyses of the learner in form of NEEDS ANALYSIS/ASSESSMENT. This phase of an Instructional

Design (ID) process attempts to define the problem by asking questions like: "What is the problem?," "Is instruction THE optimal solution?," or "What about 'On the Job Training' (OJT) or staff development/recognition?" The next phase in the ID process is the TASK ANALYSIS. This phase starts where the needs analysis phase stops. It deals with problems such as the performance requirements for this job, task, and/or responsibility. Task analysis is the behavior to be attained at the end of the instruction. The last phase is the INSTRUCTIONAL ANALYSIS. This phase starts where task analysis ends. It attempts

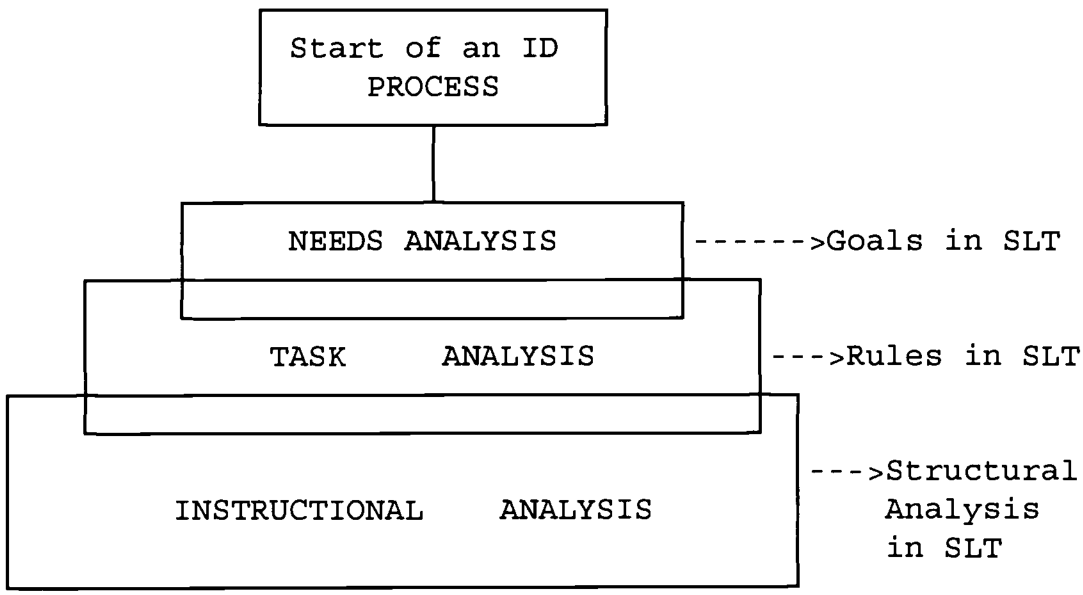

Figure 1: <u>Interrelationships Among the ID Components</u>

FIGURE 1 IS WHAT SCANDURA TRIES TO EXPLAIN WITH HIS "GENERAL METHOD OF ANALYSIS" OR THE <u>STRUCTURAL ANALYSIS</u>

to determine what the learner need(s) to learn in order to meet the performance criterion (criteria) for this job, task, and/or responsibility. That is, it tries to ascertain what the learning requirements are for the attainment of the desired objective(s), or what learning outcomes must be achieved and in what sequence. Schematically, the interrelationships among these ID components is as shown below.

1.4.1 Teaching Cognitive Strategies:

According to Scandura (1983), structural learning theory's high priority is to have a sound conceptualization of the learner's internal cognitive processes when designing instruction and that merely having techniques and methods are not enough. Cognitive strategies are guiding procedures that students can use to help them complete less-structured tasks such as reading comprehension, study skills, and writing. There are some academic tasks, such as mathematical computations or map skills, that are well-structured. That is, these tasks can be broken down into a fixed sequence of sub-tasks and steps that consistently lead to the same goal. Long-division is an example of a well-structured task. These well-structured tasks are taught by using algorithms; by teaching the students each step of the algorithm. Cognitive strategies are heuristics. A cognitive strategy is not a direct procedure. It is not an algorithm to be followed precisely. Rather, a cognitive strategy is a heuristic or guide that serves to support or facilitate the learners as they develop internal procedures that enable them to perform the higher-level operations. Teaching students how to generate questions about their reading is an example of a cognitive strategy

1.4.2 Techniques for Teaching Cognitive Strategies:

There has not been a generally well established way to teach cognitive strategies. Most instructors adopt a technique that is suitable to their audience. The following is a list of suggestions to supplement the technique the instructor might have developed:-

- Mastery of Knowledge: Review homework assignments and relevant works assigned to the students, review prerequisite skills and knowledge for the lesson, review previous material before presenting new ones, and review relevant previous learning to determine students' level of understanding.
- Instructional Presentation: Present the instructional material by stating the lesson goals or provide an outline, present new materials in small steps using clear language, avoid digression, and provide both positive and negative examples.
- Provide Feedback: Provide timely feedbacks on all students' works, provide process feedback when answers are correct but hesitant, provide sustaining feedbacks, clues, or reteaching when answers are wrong, and reteach material when necessary.
- Evaluation and Supervision: Spend more time on guided practice, continue practice until students are fluent, supervise students' learning models and provide alternative models when necessary, and test and/or quiz students for understanding intermittently.

1.4.3 Instructional Ingredients:

We can all be proud of our progress as a profession. Research findings on instructional techniques justified that the fields of Instructional Systems and Educational Technology have advanced from their primitive stages to their well advanced high-tech stage (Snelbecker, 1983). Others such as Rosenshine and Meister (1994) have succeeded in finding four instructional ingredients to supplant the techniques for teaching cognitive strategies:-

(a) Provide Procedural Prompts:

Procedural prompts are concrete heuristics that students can refer and apply the cognitive strategy for better learning. Some of the best known prompts that students use are "who," "when," "what," and "why." These are question generators: "Why" do I have to learn this material? "How" can I extract the roots of this quadratic equation? "When" will I apply the subtraction or addition algorithm? "Who" came up with these rules anyway? "What" do I do after this rules are applied?

(b) Teach Micro Rules:

Partition the instructional material into equivalence classes and teach these equivalence classes using micro-rules in small steps by starting from the least and then progress to the most difficult. Link each equivalence class to the one adjacent to it by reviewing the materials of the first and introducing the ones of the next. Integrate the instructional contents of these two equivalence classes in a coherent manner to avoid confusion and distortion of the knowledge.

(c) Algorithmization and Modeling:

Use algorithms to model the process of using the cognitive strategy. Higher-order tasks have hidden steps, so sequencing the delivery of embedded instructions with atomic rules will simplify the cognitive process. It is important that the instructor model the process of developing question, summaries, and knowledge maps, as well as modeling the process of using procedural prompts for problem-solving. Furthermore, thinking aloud by the instructor and more capable students will provide the novice students with a way to observe the "expert thinking" processes. This will enhance students' metamemorial processing of information.

(d) Scaffolding and Guided Practice:

Scaffolding are the instructional aids used to teach students to develop and apply cognitive strategies. They are general guided students' practice terms (thinking aloud, algorithmization, sequencing the instruction, group dynamics, anticipating error, debugging mental models, and cognitive apprenticeship) for the various types of supports that are provided to the students (Gage & Needles, 1989).

2.0 **Research and Teaching Using Structural Learning Theory**

Major instructional advances and instructional developments in the last twenty years have been the concept of cognitive strategies. The current wave of research efforts are focusing on constructivism and systemic instructional models (Ikegulu, 1995b). This section focuses on the research efforts and findings for the past four decades. These findings are grouped in two major categories: essentials of anchored cognitive structures and research on teacher effectiveness.

2.1 Essentials of Anchored Cognitive Structures:

A major area of research, one with important implications for learning and teaching, has been the research on cognitive structures, research on how information is processed, stored, and retrieved (Scandura, 1971; Larkin & Reif, 1976). It is currently thought that the information in our long-term memory is stored in interconnected networks called knowledge structures. The size of these structures, the strength of the connection, the number of connections between pieces of knowledge, and the organization and richness of the relationships are all important for processing information and solving problems (Novak & Gowin, 1984; Scandura, 1971). Having a well-connected and structured network of prior knowledge means that any one piece of information can serve to retrieve the entire pattern (the equivalence class). And, having strong anchored cognitive structures that are rich and well-connected enables one to retrieve more pieces of the pattern (the whole equivalence classes of the knowledge). Hence, well-connected and elaborate knowledge structures are essential because they (a) allow for easier retrieval of prior knowledge, (b) facilitate the understanding and integration of new knowledge, and (c) permit more information to be processed in batches.

2.1.1 Areas of Applicability:

Typical areas where the structural learning theory can be applied are artificial intelligence (simulation and mediated instructional processes such as intelligent tutor); all Computer Assisted Instructions (CAI) and their derivatives; educational testing and measurements (mental models and individual difference measurements); and Behavio-Cognitive Psychology such as Landa's (1976) Algo-Heuristic Theory, Gagne's (1960, 1972) Genetic Epistemology, Merrill's (1973) Component Display Theory, Ausubel's (1960) Meaningful Reception Learning, and Reigeluth's (1978) Elaboration Theory. There are three important instructional implications for the application of structural learning theory:-

(a) Helps Learners Develop their Background Knowledge:

Structural learning theory supports the need for the teacher to assist learners to develop their background knowledge by providing examples and non-examples, group application and activities, testing at different levels of the instructional sequence, and rehearsal, review, comparing/contrasting, or making inferences (Scandura, 1962, 1971, 1983; Scandura & Scandura, 1980). Another area is in macro rules.

Higher-order rules are important in helping learners develop their background knowledge because they: (i) Provide a general and viable means for representing individual knowledge. (ii) Foster and enhance learner creativity. That is, allow the learner to discover or create his or her understanding of the rules as he/she sees fit. (iii) They are fully operational, that is, the complexity/simplicity of these rules helps the instructor to determine the quality of knowledge gained (or mastery of information) by the learner. (iv) Facilitate the specification of competencies in the structural analysis phase.

(b) <u>Provide for and Encourage Learner Processing:</u>

Processing of new information takes place through a variety of activities such as reading, teaching someone else, applying the newly acquired knowledge in a different context, and drawing connection from old to new information. In addition, understanding is more likely to occur when a learner is required to explain, elaborate, or defend his or her position to others. The burden of explanation is often the push needed to make the learner evaluate, integrate, and elaborate his or her knowledge in new ways (Palincsar & Brown, 1984). Structural learning theory achieves this through algorithmization of the lessons within the selected content and domain of instruction.

(c) <u>The Need and Importance of Organizers:</u>

Structural learning theory is an instructional prescription that supports learner creativity, reduces learner rate of forgetting (or recall), and fosters learner expansion of his or her long-term memorial loads. One way this is achieved is through "graphic organizers." That is, organizing structures for expository materials such as an outline, a table, or a flow chart. Another approach is to teach the learners how to develop their own graphic organizers for new materials. This process is facilitated when the teacher provides the learners with a variety graphic organizer structures that they can use to construct their own graphic organizers. In Scandura's structural learning theory, the use of micro and macro rules, selecting the domain and range of the content, defining the equivalence classes within the content, and structural analysis are some of the approaches used to provide learners with ways of developing their own graphic organizers.

2.2 Research on Teacher Effectiveness:

Although a number of studies have been conducted on effects of teachers on learners' perceived achievement, none of these studies considered the use of structural learning theory. This is one of the areas where the effects of SLT has not been documented with regards to learners' performance in a classroom environment. Most of these studies used instructional variables such as teacher's use of praise and criticism, the number and type of questions that were asked, the quality of the students' answers, and the responses of the teachers to students' answers to determine the achievement levels of the students enrolled in their classes (Barr, et al., 1948; Medley & Metzel, 1959; Flanders, 1960; Rosenshine, 1971; Brophy & Good, 1986; Rosenshine & Stevens, 1986; Gage & Needles, 1989). Research methodologies considered in the above cited research works were mostly correlational studies. Findings from these research efforts can be integrated into the research that considers structural learning theory exclusively. The implicit inclusion of these instructional variables in a longitudinal study will not only have practical implications on the effectiveness of SLT, but also the cognitive and metacognitive merits of the theory as well. Two important research designs relevant to the success of the research on SLT with regards to teacher effectiveness are:-

2.2.1 The use of Micro and Macro Rules:

In structural learning theory, rules may be broken into their ATOMIC and/or MOLECULAR components with distinct paths. Atomic rules are steps/sequences that all the target audience are assumed to have (or not have) competencies in. These are the "MICRO RULES." Molecular rules are combination of two or more atomic rules. These are the "MACRO RULES." The link from atomic to atomic, atomic to molecular, or molecular to molecular rules is the "PATH." Since the paths partition the entire domain into distinct, exhaustive, and homogeneous "EQUIVALENCE CLASSES" or minimum rational sets; and mastery of each equivalence class within a path implies mastery of all the equivalence classes in that path, success on any PATH of a rule depends on success in all atomic (or molecular) components of each path.

Categorizing the instructional materials into equivalence classes, and covering the scope of each equivalence class in a sequential manner will improve students' performance (Scandura, 1964, 1971, 1983; Ausubel, 1960; Landa, 1976; Reigeluth, 1978).

The procedure of teaching in small sequences fits well with the research findings on cognitive psychology where order and sequencing of information are very important and are exclusively reserved for certain content domains of a problem type. The use of micro and macro rules involve making some assumptions about the population of interest: (a) assumptions about the minimal capabilities of the learners, (b) assumptions about the scope of each of the content areas (Content Analysis), and (c) assumptions about and identification of the instructional sequence (Instructional Analysis) with regards to the content or domain.

2.2.2 Guided Students' Practice:

It is not a good practice to present a lesson and then ask students to practice on their own (Good & Grouws, 1979; Barr, 1948). Presenting some of the instructional materials a segment at a time (in batches) is a better approach. That is, sequencing the content of the instruction, and then guiding the students' practice is the most feasible teaching technique. This is applicable in computer assisted instruction (CAI), computer based instruction (CBI), and Artificial Intelligence and Intelligent Tutor (Durnin & Scandura, 1973). This guidance should consist of providing the students with examples and non-examples, solving some problems on the board and discussing the steps to the solutions of these problems, thinking aloud as these problems are being solved, and engaging the students in their own learning by allowing the students to solve some problems (for class critique) either individually or in groups (Ausubel, 1960; Gagne, 1968; Durnin & Scandura, 1973; Scandura & Scandura, 1980). This procedure is consistent with the cognitive model because it paves the way for the students to construct their own mental model, adjust their existing schema, and reconstruct a "NEW" schemata based on the new knowledge gained from the guidance provided by the instructor.

In summary, a research study based on Scandura' structural learning theory should make provision for extensive practice by sequencing the instructional materials, guide the students as they work through some of the problems, paves the way for students to construct their own schemata, and check the level of understanding of the student by "debugging" the errors in the students' mental models.

3.0 Advantages and Disadvantages of Structural Learning Theory

How might the results of several years of research endeavors and practice in the field of instructional systems and technology influence the application of Scandura's structural learning theory? In what ways are the differences and/or similarities of these research efforts and field experiences fit together? First, the research allows us to articulate a major goal of education: `helping students develop well-organized knowledge structures.' Structural learning theory is the first of its kind in the history of IST. An instructional theory should not be abstract to the extent that its mastery optimality should be explicit rather than implicit. Educational phenomena are not mastery events (Ikegulu, 1995a). In well-developed structures, synergism is the key - the parts are well organized, the pieces are well connected, and the links between the connections are strong. Structural learning theory enables the instructor to quickly and accurately select a content and the rules for teaching the contents. The theory is, however, not generalizable. For example, the "ALGO-VERB" and the "ALGO-SUBTRACTION" algorithms are inconsistently formulated with restricted domains. The Subtraction Algorithm is problematic when zero (0) is ontop. Structural learning theory has a wide range of applicability and, provides a process for the selection of lessons or topics from a body of knowledge as well as a method for optimal presentation of the instruction. Sequencing of the instructional material is an added advantage for SLT. Because of this sequencing technique, testing is needed for only a segmented part of the rule(s), and mastery at the macro level is indicative of mastery at the micro level of that rule. Also, both sequencing and algorithmization introduce the learner to an individualized test of key paths within the lesson plan. Thus, the structural learning theory enables the learner to retest the path that he/she has difficulty in instead of the whole test in the lesson, chapter, or topic. However, the individualization of structural learning theory is not cost-effective. Test and retest procedures within a path and/or rule are monotonous and may be prone to test bias. Also, monotony can lead to frustrations (Ikegulu, 1995a; Novak & Gowin, 1984; Scandura & Scandura, 1980).

Second, the field (practical) experiences allow us to utilize the results of the researches in meeting the educational goal by integrating the instructional design processes with our instructional specifications. Scandura's structural learning theory paves the way for the instructor to make valid assumptions about the learners' level of competence; thereby enabling the instructor to formulate a better lesson plan suitable to the target audience. In the field of IST and psychometry, the application of SLT makes it possible to formulate other cognitively oriented instructional theories. Cognitive Theory of Inquiry Teaching is an extension of SLT and item difficulties and analyses are accurately diagnosed in lesson plans based on SLT. Moreover, SLT grants the learners the added advantage to form their own schema (or schemata as in discovery learning. The inclusion of hierarchical rules allow both the instructor and the learners to form a "HOMOLOGOUS NET" of lawful relations with regards to both the content and the domain of the instruction (Ikegulu, 1995a, 1995b). Hence, mastery of the subject-matter in question is guaranteed when the selected problems are sequenced through their paths. This sequencing of instructions adopts the "Borrowing" rule which is prone to selection bias. Learners may need some sort of remediation to understand the "borrowing" concept. This remedial skills should be included as prerequisite skills.

Scandura painted a one-to-one mapping when he formulated the structural learning theory. Human behaviors do not always lend themselves to functional analogies of this type. The same is true of educational phenomena. A rule (goal) is actually a bijection, (that is, one-to-one correspondence). It is quite appalling that Scandura's theory did not make it past 1988. Literature about this theory actually stopped in 1985 after Scandura's second phase of SLT. It seems somewhat that the theory has been forgotten, not refined, and totally discarded. Therefore, the structural learning theory has no influence and applications in school settings, and as such not cumulative. Also, in as much as SLT deals with audience analyses, it did not include the background knowledge of this audience in either its original or revised versions.

4.0 Summary, Conclusion, and Recommendations

Major differences between an expert and a novice are that the expert's knowledge structure has a larger number of knowledge items or anchored schemata, the expert has more connections between these knowledge structures, and the link among the knowledge structures are stronger (Durnin & Scandura, 1973; Ikegulu, 1995a, 1995b; Rosenshine & Meister, 1995). This development of well-connected patterns and the concomitant freeing of space in the working memory is one of the hallmarks of an expert in a field. This is what Scandura tries to achieve with the Structural Learning Theory. This is what the structural learning theory's instructional prescriptions attempt to achieve with its rules and algorithms. Teaching the learners how to achieve these knowledge structures is the primary purpose of any instructional prescription. The systematic sequencing and teaching the students "how to" develop the cognitive strategies are the consequences of our of research efforts.

From my discussions in this paper, we have learned that the SLT fits well into the IST paradigm. The instructional objectives and specifications of the theory are consistent with the cognitive and information processing research findings. Techniques as to how the cognitive strategies would be taught were explored and obvious trends in the literatures reviewed were noted. The fact remains that Scandura's theory need some further refinements. It is very important to update the theory so that it could be applied in a school environment. Since the advantages of Structural Learning Theory outweigh its disadvantages, the following are recommended:-

- Widen the scope of the theory's applicability and make the theory more general with regards to its domain.
- Strengthen the demerits of SLT and amplify on its merits.
- Revise the existing theory to conform with modern technological advancements and research.
- Test the validity and reliability of the "NEW SLT" to within the confines of the `old' areas of applicability. Repeat the reliability/validity test(s) to within the confines of the newly formulated SLT. Compare/contrast between the two.

- Construct evaluation criteria using either simulation or human participants. Integrate new research efforts to include new findings.

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