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ABSTRACT

This paper introduces successive and coordinate intellectual thinking skills, using concepts as a best case example. The attributes and optimal presentation requirements of successive and coordinate concepts are reviewed, and types of errors commonly associated with successive and coordinate skills are delineated. The effects of both of these skills on the transfer of learning and training are also considered. Finally, a model structure is proposed that accommodates successive and coordinate relationships. Successive concepts are defined as having clearly distinguishable critical and variable attributes, whereas coordinate concepts have multiple, common critical and variable attributes. It is noted that learners, in classifying a concept, can either generalize to instances or discriminate non-instances. Two arguments are presented: successive concept learning should focus on generalization skill development, or the use of examples-only as an instructional strategy; and, since coordinate concepts emphasize both generalization and discrimination, they are better learned through the use of matched sets of examples and nonexamples. It is concluded that a matrix is a useful model structure that could provide for increasing discrimination along one axis and increasing generalization along the other axis. (32 references) (Author/DB)

Learning Successive and Coordinate Concepts: A Synthesis

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Running Head: Successive and Coordinate Concepts

Abstract:

In this paper, the author first introduces successive and coordinate intellectual skills, using concepts as a best case example. Next, the attributes and optimal presentation requirements of successive and coordinate concepts are reviewed.The types of errors commonly associated with successive and coordinate skills are deliniated. In addition, the author considers the effect both successive and coordinate intellectual skills have on learning transfer. Finally, a model structure that can easily accommodate successive and coordinate relationships is proposed.

Learning Successive and Coordinate Concepts: A Synthesis

A Problem That Many Seem To Ignore

In numerous instances instructional theory comes up short in dealing with intellectual skills. Frequently, the rational, or logical, classes which confine intellectual skills (e.g., concepts or rules) in a natural context are ignored, or worse, are never considered. Sometimes this omission does no harm to the instruction. On other occasions great damage is done to instruction by not heeding the inherent delineation between successive and coordinate intellectual skill learning. Regardless of the outcome, the notions of successive and coordinate intellectual skills are not even weighed in countless instructional situations.

The purposes of this paper are: (1) to state what successive and coordinate intellectual skills are, using concepts as a best case example; (2) to review the attributes of successive and coordinate concepts; (3) to discuss why successive and coordinate intellectual skills should be presented differently; (4) to contrast the types of errors associated with successive and coordinate skills; (5) to consider the effect both successive and coordinate intellectual skills have on the transfer of learning; and finally, (6) to consider a model structure that can easily accommodate successive and coordinate relationships.

Concept Learning: the best case.

In limiting the discussion in this paper to concept learning, an intended omission is committed. Gagne' (1985) considers concepts to be intellectual skill forms that both require discriminations as prerequisites and are themselves prerequisites to rule learning. Under these taxonomic conditions, concepts offer a "best case" compendium for discussion of successive and coordinate intellectual skill learning. Rules are sometimes inseparable from concepts, whereas discriminations often serve only to form concepts. Moreover, a secondary reason for highlighting concept learning is the wealth of literature available which specifically considers both successive and coordinate representations of concepts.

What are successive and coordinate concepts?

It may be most beneficial to evaluate the noun (concepts) before the adjectives (successive and coordinate). There are many verbal definitions of a concept. One particularly good one is by Markle & Tiemann (1971): A concept is a class or category all the members of which share a particular combination of critical properties [attributes] not shared by any other class. Concepts have both critical and variable attributes (Merrill & Tennyson, 1977). A critical attribute is a characteristic necessary for determining class membership of a given sequence. A variable attribute, on the other hand, is a characteristic shared by some, but not all, members of the class.

Successive concepts are thought to have clearly distinguishable critical and variable attributes, whereas coordinate concepts have multiple, common, critical and variable attributes (Shumway, White, Wilson, & Brombacher, 1983). It is important to realize successive and coordinate refer to relationships distinguished by content analysis (Tennyson & Cocchiarella, 1986). Content analysis is important because of the cognitive process of concept classification (Tennyson, Tennyson, & Rothen, 1980). Concept attainment, according to Gagne' and Briggs (1979), is measured by a student's ability to classify concept examples.

Why should successive and coordinate concepts be presented differently?

In classifying a concept, there are two kinds of relevant responses that a learner who has fully grasped a concept can make. The learner can (1) generalize to instances and (2) discriminate noninstances (Mechner, 1967). This distinction forms the basis for separating the presentation methodology for successive and coordinate concepts.

In as much as concept learning involves isolating concept attributes which may be generalized to newly encountered examples (Carroll, 1964; Gagne', 1985; Tennyson & Park, 1980), generalization skill development is crucial in learning both successive and coordinate concepts. To exhibit the attainment of the concept "sedan", the learner, shown a 1959 4-door cadillac (or a representation such as a model or a photograph) would say, "Yes, that's a sedan."

Yet, there is more. To embrace a concept a learner must do more than generalize to newly encountered examples. She must also discriminate nonmembers of that class from members (Markle,1983; Markle & Tiemann, 1971). Discrimination learning is defined by Markle (1983) as "learning to give the appropriate response in the presence of a particular stimulus which may belong to a set of rather similar stimuli" (p. 148). Show a 1963 Corvette to a teenager who really understands the concept "sedan" and she will emphatically explain to you that a Corvette is not a sedan!

Thus, both generalization and discrimination learning are required in the acquisition of concepts, in fact, all intellectual skills. Successive concepts, however, have more marked critical and variable attributes. This minimizes the problem of discriminating similar nonexamples from real examples. Successive concept learning therefore, should focus foremost on generalization skill development (Shumway, White, Wilson, & Brombacher, 1983). What may be inferred from this is the use of examples-only instruction. As an instructional strategy, teach successive concepts by using examples of the concept only. Avoid interference (proactive and retroactive) which may be introduced by nonexamples of a concept. This strategy must necessarily be a heuristic, not a hard-and-fast rule. The interference induced by nonexamples may never really be totally avoided. As Markle (1983) points out: "Any single example of any concept is ALWAYS an example of many other concepts -- its superordinates, some of its subordinates, and some classes not so logically related to it" (p. 144).

Even so, coordinate relationships are different. Coordinate relationships emphasize both generalization and discrimination. Since coordinate concepts have multiple common critical and variable attributes, they are better learned through the use of matched sets of examples and nonexamples. This instructional strategy is well-supported by both instructional theory and research (Bourne & Guy, 1968; Huttenlocher, 1962; Markle & Tiemann, 1970; Merrill & Tennyson, 1977; Wooley & Tennyson, 1972). A more formal prescription suggests coordinate concepts be taught by presenting a rational set of matched examples. A rational set (Markle & Tiemann, 1970) is a design strategy for selecting matched examples and nonexamples based on the critical and variable attributes of the concept. This method was adapted somewhat by Driscoll and Tessmer (1985) to enable the creation of examples with a wide range of difficulty.

Common Errors Associated with Concept Learning.

Three types of classification errors have been isolated by Markle & Tiemann (1970): overgeneralization, undergeneralization, and misconception. Overgeneralization occurs when the learner classifies a noninstance as an example of the concept. As can be seen from the prior discussion, overgeneralization frequently occurs with coordinate concepts. For instance, a convertible automobile could easily be incorrectly classified as a sedan of the same style and manufacturer. By matching the example (e.g., a four-door Chevrolet hardtop) with a nonexample coordinate concept (a four-door Chevrolet convertible), this error happens less often.

Undergeneralization ensues when a learner classifies examples of a concept as nonexamples. Usually, the learner fails to recognize true examples as members of a class of concepts because of generalizing too narrow a sampling of the concept category. This type of error is likely to materialize with successive concepts since the concentration here is with examples only. Undergeneralization errors may be reduced by presenting a divergent parcel of examples that range in their variable attributes. For instance, in teaching the concept of a sedan avoid presenting examples that are all green.

Misconception errors combine both undergeneralization and overgeneralization. When both of these errors occur simultaneously, the instruction may be considered really wanting. In this case, the student incorrectly assumes that one of the variable attributes is critical. On that account, nonexamples are classified as examples and examples which don't have the "false critical" attribute are considered nonexamples. Misconceptions are a little more difficult to pinpoint than either of the other two errors. For example, if we assume that a sedan is a vehicle with a permanent top, two or four doors, and a single enclosed compartment, some of the newer four-door pick-up trucks may be classified incorrectly as sedans. In contrast, enclosed covered chairs designed to transport a person and borne on poles by two men may be incorredctly classified as noninstances. In these cases, the "closed comparment of a motor vehicle" is falsely considered the critical attribute of a sedan.

Successive and Coordinate Relationships and Learning Transfer.

Two types of transfer learning, vertical and horizontal, have been distinguished by Klausmeier (1979). With vertical transfer, learners move from one level of concept attainment to another. That is, information is transferred from one level to another. This variety of transfer may have been based on Gagne's (1965) notion of vertical transfer which is related to the analysis of learning outcomes. Vertical transfer occurs when a 'chunk' of knowledge or a skill facilitates the acquisition of a superordinate skill. For instance, a learner who is adept at identifying essential schematic symbols may more rapidly learn to identify complete circuit configurations.

Horizontal transfer, as presented by Klausmeier's (1979) Concept Learning and Development Model, requires the attainment of related, as opposed to superordinate or subordinate, concepts. So, for example, the initial learning of the concept of negative reinforcement should facilitate transfer to coordinate concepts such as punishment or the Premack principle. Again, Gagne's (1965) notion of lateral transfer is comparable. Gagne' specifically refers to lateral transfer as "a kind of generalizing that spreads over a broad set of situations at roughly the same 'level of complexity'" (p. 231).

The relational analogy between successive and coordinate concepts with vertical and horizontal transfer is more than coincidental. Successive concepts with their almost total emphasis on generalization present a clear picture of vertical transfer. Whereas, coordinate concepts which must proceed toward generalization concomitantly with discrimination learning, would seem to necessitate horizontal or lateral transfer.

According to Royer (1979), vertical transfer has received the bulk of attention from both psychologists and educators. Two of the reasons he offers are: (1) The ill-suited nature (for analyzing lateral transfer) of the historically dominant theoretical perspective for viewing transfer problems and, (2) the lack of concern by educators with determining whether school-learned skills transfer to real-world tasks.

A Model for Teaching Successive and Coordinate Intellectual Skills.

The obvious implication of Royer's comments is the need to apply micro-based prescriptive models which approach the teaching of concepts in a way that optimizes what Markle (1977) refers to as conceptual networks. The constructs of successive and coordinate concepts and vertical and horizontal transfer are, after all, merely relational structures devised to incorporate knowledge into an ever-changing and highly complex human memory. The proper presentation sequence to incorporate concepts is pivotal. According to Carroll (1964), the difficulty students have with concept acquisition is probably related to the errors teachers make in presenting the proper sequence of information.

The Matrix, a Model Presentation Form.

From the above discussion, it may be suggested a model is needed that can accommodate the vertical and lateral flux required in teaching successive and coordinate sequences. In considering the familiar structures available to us for this purpose, one which stands out is the matrix. A matrix as a useful model structure could be envisioned this way: an axis of "N" concepts providing for increasing discrimination is crossed by "N" levels of progressive difficulty providing for increasing generalization on another axis. The discrimination axis may be aligned with horizontal transfer. The generalization axis may be related to vertical transfer. Properly sequenced, a matrix model would provide for concept instances (and noninstances) which suffice for either successive or coordinate relationships.

One such model, the Rational Set Generator has been proposed by Driscoll and Tessmer (1985a; 1985b). This matrix (see figure 1) has been used in several experiments (e.g., Dempsey & Driscoll, 1989; Dempsey, Tucker, & Nicholas, 1990) and has resulted in significant increases in learning. Model matrices, such as the rational set generator, are able to expand and contract depending on the number of concepts or rules in the rational set. The difficulty (generalization) levels are also highly variable. Although Figure 1 is square, there is no requirement for an equal number of concepts and levels of generalization. The matrix structure, being pliable, is open to empirically-based schemes to establish the number and difficulty levels of the relevant skills (see Litchfield, Driscoll, & Dempsey, 1989).In teaching coordinate concepts, the number of concepts responds to Markle and Tiemann's (1970) prescription for the use of rational sets of concepts and Gagne's (1965) notion of lateral transfer. The difficulty levels attend to Gagne's theorization of vertical transfer and its relation to levels of complexity.

Figure 1 About Here

Successive concepts may also be taught with a matrix. In this case, examples may be presented to learners in progressive levels of difficulty, one concept at a time. This method escorts the notion of vertical transfer. Moreover, by presenting related, although not coordinate, concepts within the same matrix, lateral transfer is not ignored.

In addition, matrices such as the rational set generator have the capacity to easily create "decks" or item pools of examples correctly positioned in specific research-based matrix "cells". This effectively adds a third dimension to the matrix. Thus, the matrix may be used to create a library of examples for teaching and testing successive and coordinate intellectual skills.

<u>Summary.</u>

More than one theorist (Kelly, 1967; Winkles, 1986) has supported the proposition that only prerequisite knowledge (essential for a certain piece of new learning) and beneficial knowledge (helpful but not essential) are "sound concepts" worthy of instruction. The matrix, and in particular the rational set generator, is offered as a model which nurtures both prerequisite and beneficial knowledge.

The constructs discussed in this paper (i.e., discrimination and generalization skills; successive and coordinate concepts; vertical and lateral transfer) have a great deal to do with the development of intellectual skills. Regardless of the quality of instruction created by trainers and educators, the scope and sequence of intellectual skills are critical considerations. Even though the actual instruction may be exquisite, the natural contexts of learners' needs mandate that we structure intellectual skill acquisition in a fashion which adapts to varying needs.

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