Handbook of Individual Differences, Learning, and Instruction

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INDIVIDUAL DIFFERENCES AND INSTRUCTION

Introduction

The major assumption of this chapter, as well as a major assumption of this book, is that it is possible and desirable to adapt the nature of instruction to accommodate differences in ability, style, or preferences among individuals to improve learning outcomes. In the previous chapter, we discussed the following assumptions that underlie this belief:

- Different learning outcomes require different skills or abilities.
- Individuals differ in their abilities to process information, construct meaning from it, or apply it to new situations.

In this chapter, we discuss the following assumptions that underlie the goal of adaptive instruction (later, we also discuss impediments to this goal):

- Learning outcomes may be fostered or taught in many ways through the use of different microlevel and macrolevel strategies.
- These different forms of instruction require different learning aptitudes, abilities, styles, or preferences. That is, individuals will respond to different forms of instruction in different ways.
- Learning outcomes are affected by the form of instruction. So, different instructional activities will differentially affect learning outcomes.

As in the previous chapter, we treat each of these variables separately. First, we look at the range of instructional strategies and tactics. Then we describe how those instructional techniques interact with learner traits. In the next chapter, we discuss macrolevel strategies for intentionally adapting those strategies to meet the needs of different learners.

Instructional Strategies and Tactics

Instruction may be accomplished in many ways; that is, as teachers or designers, there are many different strategies that we can employ to help
learners acquire knowledge. Instructional strategies represent a set of decisions that result in a plan, method, or series of activities aimed at obtaining a specific goal (Jonassen, Grabinger, & Harris, 1990). This definition is derived from its historical use as a term that represents an overall plan, for instance, to win a game. In tennis, the strategy is an overall plan of action to win a match. The tactics represent specific actions that are well rehearsed and are used to enable the strategy. For example, a player may decide to rush the net to effect a strategy of keeping an opponent off guard. A strategy is like a blueprint; it shows what must be done but does not tell how to do it. Instructional strategies do not describe how to deliver instruction, but rather how to organize, sequence, and present it. An instructional strategy may recommend motivating the learner prior to instruction. This may call for tactics such as arousing learner uncertainty, asking a question, or presenting a picture. A strategy aimed at teaching a concrete concept may call for the use of tactics, such as matched example/nonexample pairs, or deriving the criterial attributes from a set of examples. Instructional strategies provide the overall plan that guides the selection of instructional tactics which facilitate learning. Tactics are those learner/teacher activities in a lesson that facilitate a variety of instructional events, such as:

- using graphic organizers to introduce a lesson
- asking learners to summarize a text passage
- informing learners of the goal of a lesson

Next, we present the taxonomy of instructional strategies and tactics (Jonassen, Grabinger, & Harris, 1990). As we reviewed in the previous chapter, a taxonomy is a classification scheme for conceptually describing a domain of objects, ideas, or organisms. Objects or ideas are grouped together based on shared characteristics. The shared characteristics or attributes form the classes that organize the domain of information. This taxonomy groups instructional strategies into four main classes: contextualizing instruction, providing learner control, organizing and cuing learning, and assessing and evaluating learning. These classes of strategies are not descriptive enough to be useful for designers. Subsumed by these classes are the actual instructional strategies. These instructional strategies have been proposed and researched by designers and educational psychologists. All are supported by research, a review of which is beyond the scope of this book. These strategies are implemented, in different instructional situations, in the form of instructional tactics. This taxonomy subsumes instructional tactics under the strategies, as specifications of those strategies.

In the following taxonomy of instructional strategies and tactics (reprinted with permission of NSPI), classes of strategies are presented in bold italics; instructional strategies are presented in bold; and tactics are in plain text style.
Contextualizing instruction

Gaining the attention of the learner
- arouse learner with novelty, uncertainty, surprise
- pose question to learner
- ask learners to pose questions to be answered by lesson

Relate the goals of instruction to the learner's needs
- explain purpose or relevance of content
- present goals for learner to select
- ask learners to select own goals
- have learner pose questions to answer

State the outcomes of instruction
- describe required performance
- describe criteria for standard performance
- ask learners to establish criteria for standard performance

Present advance organizers
- verbal expository: establish context for content
- verbal comparative: relate to content familiar to learner
- oral expository: establish context for instruction
- oral comparative: relate to content familiar to learner
- pictorial: show maps, globes, pictures, tables
- adapt context or provide a variety of contexts for explaining content

Present structured overviews and organizers
- present outlines of content: verbal
- present outlines of content: oral
- use graphic organizers/overviews

Providing learner control of instruction

Elicit learner approaches
- review prerequisite skills or knowledge
- ask learners to select information sources
- ask learners to select study methods
- ask learners to estimate task difficulty and time
- ask learners to monitor comprehension
- ask learners to relate questions to objectives
- ask learners to recall elaborations
- ask learners to evaluate meaningfulness of information

Elicit recall strategies
- rehearse, repeat, reread
- use mnemonic strategies
- use cloze reading activities
- make identifications with location or room
- create summaries: hierarchical titles
- create summaries: prose
- create summaries: diagrammatic/symbolic (math)
- create summaries: mind maps
Enable learner elaborations

create images
infer from information
generate analogies
create story lines: narrative descriptions of information

Learning Organization: Structured Cues to Context

Vary lesson unit size
large chunks
small chunks

Preteach vocabulary
present new terms plus definitions
ask students to look up list of new terms
present attributes of rule definition, concept, principle
paraphrase definitions
derive definitions through concept analysis
derive definitions from synonym list

Provide examples
provide prototypic examples
provide matched example/nonexample pairs
provide divergent examples
provide close-in nonexamples
vary the number of examples
model appropriate behavior

Use cuing systems
provide graphic cues: lines, colors, boxes, arrows, highlighting
provide oral cues: oral direction
provide auditory cues: stimulus change (e.g., music, sound effects, voice change)
provide type-style cues: font changes, uppercase, type size, headings, numbering
present special information in windows

Help learners integrate new knowledge
paraphrase content
use metaphors and learner generated metaphors
generate examples

Enable learner elaborations
identify key ideas
create content outline
categorize elements
use pattern note techniques
construct graphic organizers
construct concept map

Advise learner
advise about instructional support: number of examples, amount of practice, tools, materials, resources, strategies
Assessing Learning

Provide feedback after practice
provide confirmatory, knowledge of correct response
provide corrective and remedial feedback
provide informative feedback
provide analytical feedback
provide enrichment feedback
provide opportunities for self-generated feedback

Provide practice
provide massed practice sessions
provide distributed practice sessions
provide overlearning
apply in real-world or simulated situations (near transfer)
change context or circumstances (far transfer)
vary the number of practice items

Testing learning
pretest for prior knowledge
pretest for prerequisite knowledge or skills
pretest for endpoint knowledge or skills
embed questions throughout instruction
use objective referenced performance
use normative referenced performance
use incidental information, not objective referenced

This list of instructional strategies is not exhaustive, but it does represent the range of instructional activities or treatments. An information-processing analysis of all of these treatments would be necessary for providing any recommendations on their specific use in facilitating instructional outcomes or meeting the needs of individual learners. Such an analysis would fill a book longer than this one. The next section describes how these treatments may interact with various learner traits. Each treatment will have different effects on different learners, or different learners will profit more from certain different strategies and tactics.

Aptitude-by-Treatment Interactions

The concept of aptitude-treatment interactions (ATI) is one of the best known in the educational research field today. It began when Cronbach (1957) used a correlational approach to relate individual differences and achievement on different experimental treatments. Cronbach and Snow (1969) laid the groundwork for contemporary ATI research by suggesting methodological and conceptual guidelines for its conduct. In essence, ATI is a research methodology that explores interactions between alternative aptitudes (Cronbach & Snow, 1969), attributes (Tobias, 1976), or traits (Berliner & Cahen, 1973) and alternative instructional methods.
Aptitudes refer to any of the personological variables (such as mental abilities, prior knowledge, personality, or cognitive styles) that were listed in chapter 1. Treatments consist of the structural and presentational properties of instructional methods such as those described previously in this chapter. Interactions occur between aptitudes and treatments when individual differences in the former predict different outcomes from alternative forms of the latter. That is, instructional treatments may either facilitate or inhibit learning depending upon the effects of their structural characteristics on different types of learners.

To understand ATIs, it is necessary to understand the rudiments of a statistics-based research methodology known as regression analysis. Regression analysis is a method that seeks to ascertain the predictive effects of one variable on another, for instance, the effects of intelligence on achievement. To determine whether intelligence as a general learner trait has an effect on achievement, we must first measure intelligence, say, in terms of IQ, and then measure achievement, say, a test of mathematics achievement, following instruction in which the learners were given no remedial help. Both scores for each individual are then plotted on the axis of a two-dimensional graph, such as Fig. 2.1. Each dot on Fig. 2.1 represents the intersection of an individual's scores on both tests. Move upward along the achievement line to find the student's score and then across the intelligence line to the student's IQ. Next, identify the intersection of those two points on the graph. Each dot in the figure represents an individual's combination of scores. Regression analysis identifies a regression line that minimizes the differences in the points on its regression line. In this case, the regression line has a positive slope. This indicates that as the intelligence scores increase, achievement scores also increase. We can conclude from Fig. 2.1 that intelligence has a positive effect on achievement when the learners are given no special help.

Suppose that to help the less intelligent learners achieve higher math scores we devise a primary treatment that provides practice followed by feedback (knowledge of the correct answer). Results from this treatment are then compared with those of another group of learners given the original no-help instruction. This produces two regression lines in Fig. 2.2 -- one for the practice treatment (Treatment 1) and one for the no-help group (Treatment 2). It is obvious the practice treatment helped the learners. The less intelligent learners performed better in Treatment 1 than in Treatment 2. Notice also that the more intelligent learners performed better than the less intelligent learners in both groups. In this case, because the slopes were the same, the effects of intelligence on math achievement were the same, regardless of the nature of instruction.
In another case, we decide to develop a superinstructional treatment, including analogies, graphic organizers, and practice with corrective and remedial feedback, to improve the achievement of the less intelligent students. We measure IQ, teach one group of students using the Super Treatment and another group with the No-Help Treatment and then measure math achievement and plot the results in Fig. 2.3. This plot shows that the treatments variably affected different learners because the slope of the regression lines are different. In the case of the No-Help Treatment, students with higher IQs performed better; however, in the Super Treatment, students with higher IQs performed more poorly (as indicated by the negative slope). We finally found a treatment that helps lower IQ students perform as well or better than higher IQ students. This situation indicates the existence of an ATI. Different instructional treatments produced varied effects on different types of learners.
The ATI in Fig. 2.3 is a disordinal interaction. This means that not only were the regression slopes different, but they also intersected. This is less common than an ordinal interaction (as shown in Fig. 2.2) where the regression slopes are different (indicating different effects of treatments) but do not cross.

There is a growing body of research on ATIs where variably designed instructional methods have produced different interactions with different types of learners. For example:

- Qualitative data (analysis of a think-aloud protocol) indicated an interaction between fear of failure and structuring of instruction. Those subjects with a high fear of failure did not learn well in an unstructured instructional condition (Kamsteeg & Bierman, 1989).

- The cognitive restructuring ability of the learners interacted with levels of teacher guidance for items having continuous perceptual distracters (Cramer, 1989).
- Learners with different cognitive entry behaviors (CEB) were differentially affected by mastery versus nonmastery learning strategies among third graders on comprehension achievement (Chan & Cole, 1987).

- Eight problems in drawn versus verbal versus telegraphic formats were administered to 854 students in grades three through seven. Readers of high ability chose correct operations more often than low-ability readers. The drawn format was better for low-ability readers than high-ability readers (Moyer, 1984).

- Instruction that included the use of metaphors was helpful to students with a preference for a visual format (visualizers) but not to those with a preference for a verbal format (verbalizers) (de Klerk, 1987).

- Field dependent subjects had faster response times and fewer response errors when given an explanation of their errors and strategies for correcting them, whereas field independent subjects had lower response rates and fewer errors when given only an indication that an error had been made.
These examples of ATIs from the research literature are descriptive of the variety of effects that may occur. The implications of these results for instruction are obvious. If we can identify instructional treatments that facilitate learning in different learner types, we can adapt our instruction accordingly. Indeed, there has been much interest in adapting instructional methodologies to accommodate individual learner characteristics based on aptitude-by-treatment interaction research. Individual differences identified by this field have obvious implications for the design of individualized systems of instruction. "All attempts to individualize instruction, it turns out, rest explicitly or implicitly on some kind of ATI idea" (Snow, 1977b, p. 23). Many designers have assumed that ATIs that are conceptually coherent and can be consistently generated will provide guidelines for accommodating the individual differences they assess.

**Limitations of ATIs**

Extensive reviews of ATI research (Berliner & Cahen, 1973; Bracht, 1970; Cronbach & Snow, 1977) found what Bond and Glaser (1979) indicated are "mostly A and T with not much I." The lack of consistent support for the ATIs has resulted from the weak conceptual grounding and deficient methodology often employed in many of the research studies. Small samples sizes, abbreviated treatments, specialized aptitude constructs or standardized tests, and a lack of conceptual or theoretical linkage between aptitudes and the information-processing requirements of the treatment further compound the inconsistencies in research findings.

**ATI research is largely atheoretical.** Although a major goal of ATI research has been the identification of explanatory principles concerning the nature of instruction (Salomon, 1972), most studies have focused on the predictive relationships of aptitudes to assign subjects to different treatments. Although Berliner and Cahen (1973) advised that an "understanding of the psychological processes of a specific learning task is prerequisite to the development of a theory on the interaction between traits and treatments," previous ATI research was often conceived without this understanding (p. 59). Without an adequate conceptual basis for selecting aptitude variables, researchers have often resorted to a shotgun approach. The need for a better conceptualization of treatments, which considers the information-processing requirements called on by the treatments, is one of the most persistent issues in ATI research (Fagan, 1979). Recent models have sought to overcome this problem. If ATI research is to be fruitful, DiVesta (1975) claimed that the "theory underlying ATI research must consider the cognitive processes assumed to be correlated with the traits and/or processes induced by the treatments" (p. 189). This assumption led to his search for TTPIs (trait-treatment-process interac-
ATI results lack consistency. Tobias (1981) concluded from several studies that ATI results were generally inconsistent. Significant interactions are offset by other nonsignificant treatment differences. Very few replications of ATI research have yielded significant interactions. In fact, many replications have reversed the findings of the previous study or were followed by non-significant differences. Tobias has also found that different researchers evaluating the same aptitudes or treatments produced dissimilar results. When ATIs do occur, most are not strong; that is, they are not disordinal and therefore are not useful for differential assignment. Results are often isolated and full of artifacts. When meaningful conceptually based aptitudes and treatments are employed, however, replications may occur (Peterson, Janicki, & Swing, 1980).

ATI results lack generality. In addition to the lack of consistency, most ATI results cannot be generalized to similar populations across time. They lack what researchers call external validity. Many ATI studies are not classroom-based. When they are, class effects often interact with treatments or aptitudes. The social context of the classroom plays an important role in learning, although it adds another order to the interactions. The interactions both among and between aptitude variables and instructional conditions are so complex as to render generalization impossible (Snow, 1977a). It is impossible "to store up generalizations and constructs for ultimate assembly into a network" (Cronbach, 1975, p. 123). A generalizable theory of aptitude-treatment interactions may not be possible. Learning may be too context-specific. At best we can hope to develop local instructional theories related to local instructional situations concerned with small portions of the curriculum and small segments of the population (Snow, 1977a). Snow concludes that it is possible, through continuous, systematic, formative evaluations of ATIs over time in a given place, to generate a dynamic instructional theory for that place alone.

ATIs also do not generalize over time. Long-term, realistic studies suggested by Cronbach and Snow (1977) are capable of producing some interactions. For instance, Hickey (1980) found in a semester-long study that internal, high-general reasoners benefitted from low-instructional support. Unfortunately, this type of longer term interaction is subject to instability over time. For instance, over a sequence of four units, Burns (1980) found that crystallized intelligence (see chapter 4) was consistently correlated to performance, yet all other aptitudes fluctuated over time. Treatment effects may also change over longer periods of time, suggesting what Cronbach (1975) referred to as Decade X Treatment interactions. It seems that ATI effects can only be generalized to individual classes in a specific locale during a finite period in history.
ATIs also interact with task and content. ATIs also interact with processing requirements of the learning task to produce complex performance differences (Rhetts, 1974). Rhetts found that error rates were higher but response latencies were shorter for impulsive learners (see chapter 9), with opposite results for reflectives. Aptitude-by-treatment-by-subject (task relevant) interactions were also reported by Tallmadge, Shearer, and Greenberg (1968). In fact, Rhetts (1972) and DiVesta (1975) recommended that designers first concentrate on the task characteristics (e.g., demands on memory, as described in chapter 1) and then identify the individual difference variables that may be related to those characteristics. This additional level of interaction is not surprising. It simply adds complexity and ambiguity to an already uncertain process. The major issue here is how designers or teachers can be expected to effectively adapt instruction to aptitude x, treatment x, class x, time x, and context x task interactions in designing instruction for each objective.

Conclusion

The ultimate purposes of ATI research are (a) to better understand learning processes and the role of individual differences in those processes, and (b) to make prescriptions about which instructional activities will best bring about those processes. Chapter 1 briefly described the range of learner traits and the differences in processing required by different learning outcomes. It also described how these learner traits can interact with learning outcomes. This chapter reviewed a range of instructional treatments that can be used to facilitate the accomplishment of those outcomes and how the instructional variables can interact with learner traits. Knowing how learner traits interact with outcomes will help us to determine the degree of assistance that learners require to accomplish them. Knowing how learner traits interact with instructional treatments will help us to determine the types of instruction that are most productive for individual learners. The purpose of this knowledge is to adapt instruction to learners' needs. The models and methods for those prescriptions are described in the next chapter.

The limitations of ATI research described earlier affect the prescriptions about adapting learning outcomes to learner traits as well as adapting instructional treatments to learner traits. Both types of prescriptions have been limited by the lack of clarity of instructional treatments and the lack of clarity of learner traits. Without clear descriptions of learner traits and replicable forms of instruction, we cannot develop meaningful and replicable prescriptions for adapting instruction. A major purpose of this book is to clarify learner traits and describe how they may interact with different learning outcomes and different forms of instruction. In nearly every chapter, we review research on the interactions between the learner trait being described in that chapter and learning outcomes. We also review
the research on interactions between the learner trait being described in the chapter and various instructional treatments. In both cases there is rarely enough quality research to make replicable predictions about how to adapt instruction or learning outcomes. Based upon the available research and a rational analysis of the learner trait being described, we offer predictions about these interactions that have a probable relationship. These prescriptions may provide hypotheses for research and some guidelines for the teacher or designer to begin thinking about how to adapt instruction. Even a simple awareness of learner traits and the possible interactions with learning and instruction will improve our understanding of those processes and the quality of our educational efforts.

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