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Adapting Instruction To Individuals: Based on the Evidence, What Should It Mean?

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We examine the argument that teaching will be more effective if adapted to individuals -what we call the interaction/adaptation hypothesis. What is likely correct about this hypothesis (but needs more research) is that modality of instruction may need to be adapted to certain types of content (e.g., geometry vs. literature) or to domain of objectives (e.g., cognitive vs. psychomotor). What is also correct (and has much empirical support) is that instruction needs to be adapted to the learners' prior knowledge and experience vis-avis the material to be learned. What is incorrect is that instruction should be adapted to learners' styles. We describe some of the major historical conceptualizations of adapting to individual differences, including summaries of the empirical evidence on these approaches. Finally, we offer an alternative approach--namely adapting to individuals' prior knowledge.

The argument that teaching will be more effective if it is adapted to the needs of individual learners is undoubtedly true, but the instructional inferences typically drawn from that fact are unsupportable. Unsupportable inferences include that instruction should be differentiated or adapted to students' learning styles, aptitudes, personalities, hemispheric preferences, intelligences, or other dispositional traits. For example, a person high in mathematical intelligence would learn best about music when instruction focuses on concepts from the mathematical domain (e.g., ratio of beats per measure), while the kinesthetic learner would learn better by actually playing a basic instrument (e.g., the tambourine), and the visual learner would benefit more from observing music being performed than from listening to a recording. Similarly, a person high in linguistic intelligence may understand math better when examples are presented in a verbal rather than mathematical form, or that someone with strong interpersonal abilities would learn more about history when instruction includes more details about the personal lives of historical figures. These types of assertions—no matter how apparently reasonable or satisfying they seem—are empirically incorrect (e.g., Willingham, 2005).

This notion, which we shall call the adaptation/interaction hypothesis, has long been a pervasive idea in education. In different decades it has been called adapting instruction, aptitude-treatment interactions (ATIs), trait-treatment interactions (TTIs) and, currently, differentiated instruction. As defined by Heacox (2002), providing differentiated instruction "means changing the pace, level, or kind of instruction you provide in response to individual learners' needs, styles, or interests" (p. 5), with styles being defined as "where, when, or how a student processes information" (p. 8). Similarly, Tomlinson (1999) identifies "what," "how," and "why" as the foundations of differentiation (pp. 48-49). Furthermore, another popular resource by Gregory and Chapman (2002) also stresses the importance of learning styles differentiating instruction.

Unfortunately (to paraphrase Santayana), those who cannot remember their research history are condemned to repeat it. And our research heritage includes a large corpus of very good quality research that failed to find interactions between learner traits and teaching methods (e.g., Cronbach & Snow, 1977), despite adequate reliability of the measured traits. Instead—and this is good news—treatments that are effective for one type of individual tend to be effective for others as well; that is, treatments show significant main effects on achievement, not aptitude-treatment interaction effects.

What is likely correct about the interaction/adaptation hypothesis (but needs more research) is that modality of instruction may need to be adapted to certain types of content (e.g., geometry vs. literature) or to domain of objectives (e.g., cognitive vs. psychomotor). What is also correct (and has much empirical support) is that instruction needs to be adapted to the learners' prior knowledge and experience, prerequisite cognitive strategies, and emotional readiness (e.g., are there symptoms of learned helplessness?) for the material to be learned.

It is our purpose in this article to describe some of these historical conceptualizations of adapting to individual differences, followed by a brief summary of the empirical evidence on these approaches. Then, we shall offer an alternative interpretation of adapting instruction to learners that respects their individuality (rather than grouping them by traits for instructional purposes, as ironically embodied in the adaptation/interaction approaches).We finish with some general implications.

Cognitive Style and Aptitude

The debate over whether intelligence is a single trait or composed of multiple factors dates back at least to Spearman (1927). Not surprisingly, those who advocated multiple factors attempted to relate such factors to learning and instruction. Over time, various models and theories have been proposed, with the seminal work on individualized learning done by Guilford (1967), Cronbach and Snow (1977), and Messick (1976). Each present models that are intended to predict, based on individual characteristics, the extent to which someone would benefit from a particular type of instruction in a given area.

Guilford (1967) was arguably the most ambitious in attempting to identify and reliably measure intellectual traits. His model included five operations such as memory and divergent thinking, four content areas such as symbolic and semantic, and six products such as classes and relations. These inter-related dimensions could be combined in 120 (5x6x4) combinations that represent distinct intellectual abilities (e.g., divergent thinking/relations). Each of these, in theory, could be used to predict a person's potential to learn or solve problems and, therefore, provide the learner a differential diagnosis and instructional prescription (though that was not Guilford's primary concern).

Going beyond the intellectual abilities identified by Guilford, Messick (1976) combined them with personality traits into what he labeled *cognitive styles*. This more inclusive construct was defined as follows: "Cognitive styles…appear to serve as high-level heuristics that organize lower-level strategies - often including abilities - in such complex sequential processes as problem solving and learning" (Messick, 1976, p. 9). To further delineate the difference between ability and style, Messick offered distinctions in terms of quantity and value:

> Abilities are value directional: having more of an ability is better than having less. Cognitive styles are value differentiated: each pole has adaptive value in different circumstances. The high end of ability dimensions is consistently more adaptive, whereas neither end of cognitive style dimensions is uniformly more adaptive; in the latter case adaptiveness depends upon the nature of the situation and upon the cognitive requirements of the task at hand. (p. 9)

Messick went on to identify 25 dimensions including *field independence* versus *field dependence, constricted* versus *flexible control, and risk taking* versus *cautiousness.* Consistent with the assertion that there is no value attached to being high or low on any of these dimensions, those who are field-independent focus more on discrete components of their environment while those who are field-dependent have more of a global orientation; those who are flexible can tolerate distractions during learning while those distractions inhibit learning in those who are restricted; and, risk takers are willing to take chances to obtain desired learning goals while those who are cautious focus on goals that can be achieved with a degree of certainty.

Styles or traits are typically determined by having students complete a self-report inventory, and while they are less reliable than achievement tests many inventories have been shown to have acceptable reliability (Hopkins, 1998, p. 436). Reliability of a trait is of course necessary, but not sufficient. And validity for one purpose, for example predicting career performance (Hilliard, 1995; Weiseman, Portis & Simpson, 1992) does not imply validity for another purpose (e.g., rate or ease of learning something). No one understood this better than Lee J. Cronbach (1966), the inventor of coefficient alpha (Cronbach, 1951) for measuring reliability, who also said the following about instruction:

> I have no faith in any generalization upholding one teaching technique against another….A particular educational tactic is part of an instrumental system; a proper educational design calls upon that tactic at a certain point in time in the sequence, for a certain period of time, following and preceding certain other tactics. No conclusion can be drawn about the tactic considered by itself. (p. 77)

With the accumulating evidence that various styles and abilities could be reliably identified, Cronbach (1977) teamed up with Richard Snow to collect evidence on whether and how these traits interacted with particular methods of instruction. This field of research was known as *aptitude x treatment interaction (ATI)*, in which aptitude is defined as "any characteristic of a person that forecasts his…success under a given treatment," where "personality as well as ability influences response to a given kind of instruction," and treatment is defined as "any manipulable variable" such as "pace, method or style of instruction" (Cronbach, 1977, p. 6).

The evidence was negative: while some treatments proved more effective than others for some purposes, replicable ATIs were elusive or nonexistent.

Learning Styles

Despite the seemingly definitive–and negative—evidence, the interaction/adaptation hypothesis did not go away. Rather, it re-emerged with gusto in the 1980s and '90s under the title of *learning style*. Diagnosed by a variety of assessment techniques (Keefe & Jenkins, 2000), learning styles are most commonly identified via comprehensive self-report inventories (Dunn & Dunn, 1999). These inventories, such as the Learning Style Profile (Keefe et al. 1986-1990) which provides 23 possible scores indicating skills, responses, and preferences, are more typically known as personality inventories.

Not surprisingly, based on the multitude of individual differences presented thus far, learning styles have been conceptualized in a number of ways. Keefe and Jenkins (2000) define learning style as "characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how students perceive, interact with, and respond to the learning environment…Learning style is a gestalt that tells us *how* a student learns and prefers to learn" (p. 52, italics in original). According to Dunn and Dunn, "learning style is the way each person begins to concentrate on, process, internalize, and retain new and difficult academic information" (Dunn & Dunn, 1993, p. 2; Dunn & Dunn, 1999, p. 11; Dunn, Dunn & Perrin, 1994, p.2). They also offer this definition:

> Learning style is the way that students of every age are affected by their (a) *immediate environment,* (b) *own emotionality,* (c) *sociological needs,* (d) *physical characteristics,* and (e) *psychological inclinations* when concentrating and trying to master and remember new or difficult information or skills. Children learn best *only* when they use their learning style characteristics advantageously; otherwise they study, but often forget what they tried to learn. (Carbo, Dunn & Dunn, 1986, p. 2, italics in original)

They further identify components that make up a learning style, such as sensitivity to light and temperature; motivation and persistence; environmental structure; whether a person has a global, right-brain preference or an analytical, left-brain preference; and if perceptually a learner is primarily auditory, visual, tactual, or kinesthetic (Carbo, Dunn, & Dunn, 1986; Dunn & Dunn, 1993; Dunn et al.l, 1994), with a total of 20 different preferences (Dunn, 1999).

Other conceptions of learning style provide categories that are based on combinations of traits. A person is identified using scales that are polar in nature, such as introversion/extroversion. The Myers-Briggs Type Indicator (Briggs et al., 2001) uses four scales of preference that yield 16 possible categories or styles. A similar model that is based on the Myers-Brigg was developed by Keirsey (1998). In addition to introversion/extroversion, Keirsey's inventory categorizes people by temperament using three dimensions: a person is observant (S) or introspective (N), tough-minded (T) or friendly (F), and scheduling (J) or probing (P). A person's main orientation is either to be observant or introspective, with two respective sub-categories within each orientation. Thus a person who is observant is either scheduling (SJ) or probing (SP), while a person who is introspective is either tough-minded (NT) or friendly (NF). Keirsey (1998) describes the four resulting temperaments as: (a) *Artisans* (SP), who live and act in the present; (b) *Guardians* (SJ), who have a stoical outlook, particularly in the areas of hard work; (c) *Idealists* (NF), who are well-equipped for the difficult task of influencing people's attitudes and actions; and (d) *Rationals* (NT), who at school typically choose courses in the sciences (and mathematics) and avoid the humanities. The implication is that instruction should be spontaneous for the artisan, structured for the guardian, personal and interpersonal for the idealist, and scientific for the rational.

Unfortunately, as described in more detail later, there is very little evidence for the interaction/adaptation hypothesis in these publications, except for that provided by the foremost proponents of the position—the Dunns and their students—in mostly non-refereed journals. Further, the methodologies used in that research have been questioned (e.g., Coffield, Moseley, Hall & Ecclestone, 2004). There is independent evidence, on the other hand, that despite reliable differences in students' styles and personalities, instructional "…modality matters in the same way for all students" (Willingham, 2005, p.35; see also Kavale & Forness, 1987).

Brain-Hemisphericity

That the brain and all of its various anatomical functions is related to learning is another argument that is undeniably true, but the interactive/adaptive implications typically drawn from that fact are again unsupportable. We speak particularly of the right brain-left brain dichotomy, which has become so popular in educational circles; left brain people are logical and detail oriented, while right brain people are creative and holistic and, thus, they would benefit most from instruction which favors their preferred hemisphere. Ironically, the diagnosis of this trait rarely if ever involves measuring the brain, but rather is inferred from learners' behavior and cognitive strategies. Attempting to connect learning with the physical brain began as a result of the study of (a) brain injury, where a person lacks certain abilities because of damage to a particular area of the brain, and (b) brain surgery aimed at controlling some type of disease or disorder, in particular the severing of the portion of the brain that connects the two hemispheres (corpus callosum) and identifying where behaviors are localized. Medical advances such as PET (Positron Emission Tomography)

Scans have also contributed to the study of the physical brain in learning.

What this research indicated was that we have what is called *hemispheric specialization*.

> The left hemisphere is largely the language center of the brain and engages in logical, sequential information processing. Scientists believe that the left hemisphere is analytical and attends to detail, while the right hemisphere may be responsible for generalized concepts. Researchers believe that the right hemisphere processes sensory stimuli and thinks in pictures rather than words. It manages information in a holistic fashion; our intuitive and creative thinking is centered in this hemisphere. (Hardiman, 2003, p. 7)

Research indicating hemispheric specialization led to the development of the theory of *Hemispheric Brain*

Dominance or *Hemisphericity*

> The idea that the two hemispheres are specialized for different mode of thought has led to the concept of hemisphericity - the idea that a given individual relies more on one mode or hemisphere than on the other. This differential utilization is presumed to be reflected in the individual's "cognitive style" - the person's preferences and approach to problem solving. A tendency to use verbal or analytical approaches to problems is seen as evidence of left-sided hemisphericity, whereas those who favor holistic or spatial ways of dealing with information are seen as right-hemisphere people. (Springer & Deutsch, 1987, pp. 287-288)

While this distinction was included in the Dunn and Dunn (1999) learning styles model described earlier, it also stands as its own entity as a theoretical model (Iaccino, 1993). This view of the brain is nevertheless "simplistic" (e.g., Hardiman, 2003, p. 7) because processing during most tasks, such as spatial reasoning and visual imagery, involve both sides of the brain (Bruer, 1997). In addition, most learning tasks involve the brain stem as well, activating sites known to be associated with arousal, emotion, and other correlates of cognitive activity.

An alternative brain-based approach attempts to explain, through neuroscience research (e.g., PET scans), how the brain works and provide appropriate instruction. For example, Jensen (1996) indicates that the cortex "quests for novelty" (p. 26) so when designing lessons teachers should be "outrageous and different, *but also focus more energy on designing learner-generated projects* so that you don't have to be a 'shock-show' to run a class" (p. 27, italics in original). Caine and Caine (1990) assert 12 principles of Brain-Based Instruction that are key for effective instruction and argue that brain research should drive instruction. Ironically, Caine and Caine's (1990) principles (e.g., patterning and challenges) are touted as effective for all students, with only one exception.

So what are we to make of the brain-based rationale for right-brain/left-brain instructional adaptation? Bruer (1997) gives this example:

> When I speak to teachers about applications of cognitive science in the classroom, there is always a question or two about the right brain versus the left brain and the educational promise of brain-based curricula. I answer that these ideas have been around for a decade, are often based on misconceptions and overgeneralizations of what we know about the brain, and have little to offer educators. (p.4)

Eventually, he argues, neuroscience may have something to say about teaching practice, but for now such inferences are "a bridge too far." Bruer goes on to argue that, in any case, what are usually cited as principles of brain-based instruction are, in fact, principles of cognitive science. And these principles do bridge the gap between basic research and educational applications.

Multiple Intelligences

Perhaps the most well known and widely adopted conceptualization of individualization is Howard Gardner's Multiple Intelligences (Gardner, 1983; 1993). Each of his domains of intellectual capacity is expected to be relatively independent from the others, which also implies that individuals would show very different profiles of strengths and weaknesses across them. The eight domains follow: Linguistic, Logical-Mathematical, Spatial, Musical, Bodily-Kinesthetic, Interpersonal, Intrapersonal, and Naturalistic.

In keeping with his emphasis on multiple and distinct intelligences (and consistent with Messick's cognitive styles) no importance is attached to the ordering of the list. Furthermore, each is a domain for *biopsychological potential* (Gardner, 1993, pp. 36-37). That is, for biochemical and/or environmental reasons, an individual may be *at risk*, more or less in the average range, or *at promise* with regard to one of these intelligences (Gardner, 1993, p. 29). "At risk" individuals have some disability for that intelligence and need special help, where appropriate remediation can be found, if they are to achieve acceptable levels of skill in this area. Gardner gives such examples as autistic children as being at risk for interpersonal intelligence, or people with specific brain dysfunctions (e.g., aphasia) as being at risk in linguistic intelligence.

"At promise" individuals, in contrast, are those who exhibit special talent for an intelligence and have little or no need for formal teaching. These are people who come by their gifts without tutelage, though good schools might be helpful to develop their talents fully. For the in-betweeners - the rest of us - Gardner and his colleagues believe that the right kind of education is necessary.

Two points need to be made about multiple intelligences in the current context: First, the intelligences have not proven to be as uncorrelated as researchers would like in order to consider them separate and unique intelligences. In the long run, this may prove to be a fatal flaw in the theory if, for example, it can be shown that a smaller number of factors can account for the same data more parsimoniously (as Gardner & Hatch, 1999, themselves recognized). Second, while many educators might be tempted to think of the multiple intelligences as traits to which instruction might be adapted (i.e., persons high on interpersonal intelligence should be instructed in cooperative groups, etc.), Gardner did not fall into the adaptation/interaction trap. Rather, he advocates that these intelligences be used to expand teachers' repertoires of instructional methods and materials, offering more opportunities for learners to see and explore multiple ways of learning (Gardner, 1993).

Intellectual Styles

The most current and extensive review of empirical research on learning/cognitive styles is Zhang and Sternberg's *The Nature of Intellectual Styles* (2006). Their in-depth examination of this body of literature reflects the numerous variations and conceptions of styles and the ways they have been studied. They conclude that a number of styles are distinct from others and can be reliably measured, although there is, at times, overlap due to differences in the instruments used to measure them. Interestingly, however, Zhang and Sternberg depart from the traditional perspective (e.g., Messick, 1976) with respect to the value of a particular style. They report that particular styles are related to desirable characteristics while others are related to less desirable characteristics. To this end, they identify three overarching styles:

- *Type I*-styles that are perceived as more positive because they generally have more adaptive value.
- *Type II*-styles that are considered more negative because they generally carry less adaptive value.
- *Type III*-styles that are value differentiated (i.e., they can be positive or negative) because they may possess the characteristics of either Type I or Type II styles depending on requirements of a task or situation. (Zhang & Sternberg, 2006, p. 4)

An example of a Type III style would be preferring to work alone versus working with others. In the case of a musician, for example, preferring to work alone may be of value when composing but not when working with an ensemble. Thus, there is no particular good or bad value without evaluating the characteristic in context.

As for Type I and II styles, they are value laden. Recall that those whose who are field *independent* focus on discrete elements of their environment, while those who are field *dependent* are more global in their focus. The former has been determined to be an example of a Type I and the latter a Type II. According to Zhang and Sternberg's synthesis of the research on this construct:

> Field independence was associated with the kinds of personality traits that are conventionally perceived to be positive (e.g., higher level of assertiveness, internal locus of control, higher level of moral maturity, optimistic in the face of threat of frustration, and a better developed sense of identity). On the contrary, field dependence was associated with the kinds of personality traits that are typically perceived to be negative (e.g., lower levels of assertiveness, external locus of control, lower levels of moral maturity, pessimism, and a poorly developed sense of identity). (p. 32)

In addition to favorable personality traits, certain types of styles, such as field independence and being reflective, are consistently associated with overall academic success (Zhang & Sternberg, 2006). This relationship extends to particular subject areas, but not as neatly as they do with personality traits. Those who are field independent tend to excel at computer programming, problem solving, math and physical science, while field dependence favors literature and the social sciences. Thus, focusing on the environment as a whole may be helpful in some disciplines and attending to discrete elements may be helpful in others. It is imperative to note that those excelling in a particular academic domain were *not* taught in a manner to capitalize on or engage their particular style, simply that achievement in a given area was associated with a particular style. While this may seem to indicate those with particular styles will naturally excel in particular domains and are doomed to fail in others, Zhang and Sternberg also report that students are able to adopt a particular style to succeed at a particular task.

Furthermore, for those students at risk for failure, it has been demonstrated that training students in a particular style can improve achievement and locus of control (Zhang & Sternberg, 2006, p. 45). This aligns with Gardner's assertion presented above that rather than adapting to particular traits, we should encourage teachers to teach in ways that will help students develop traits that are particularly effective in terms of a particular domain and/or context.

Noticeably absent from Zhang & Sternberg's chapter on student-oriented research is an examination of the interaction between aptitude and treatment, citing only one study in which achievement was superior when learning materials were matched with a particular style. This likely reflects the inconsistent outcomes of research on the interaction hypothesis (discussed below) and the consistent outcomes demonstrating the effectiveness of particular styles in terms of academic success (e.g., Boyle, Duffy & Dunleavy, 2000; Busato, Prins, Elshout & Hamaker, 2000; Collinson, 2000; Diseth, 2002), even on academic tasks that were thought to be more suited to less effective styles (Armstrong, 2000).

Research on the Adaptation Interaction Hypothesis

What is the evidence regarding the adaptation/interaction hypothesis? To help decide, we first examined the extent to which the terms cognitive style, learning style, brain-based and multiple intelligences have permeated educational literature. Second, we examined meta-analyses of empirical studies on the effectiveness of matching particular learner characteristics to methods of instruction.

To examine the volume of literature on individualization, a search of four commonly used educational databases, Academic Search Premier [1], PsychINFO [2], ERIC[3], and The Professional Development Collection[4], all of which index periodical literature, was conducted on February 6, 2007. Results of these searches are found in Table 1. Further, as a crude but reasonable indicator of the extent to which these articles were empirical in nature (if the authors conducted some type of research that was the basis for the article), these same searches were repeated with the modification that "*n*=", a very common convention for indicating the number of subjects participating in an empirical study, was in the abstract of the article. As can be seen, a relatively small percentage (approximately 3%) of these publications was empirical in nature. Thus, the majority of the literature about each of these conceptualizations of individualization is discussing its relative importance and/or how to implement it, rather than examining its validity and/or effectiveness. When all is said and done—in educational research as in life—there is a lot more said than done.

Still, there have been over 200 empirical studies and many of those have been included in meta-analyses and other reviews. As the Cronbach and Snow studies before them, the more recent attempts to adapt an instructional treatment to accommodate differences to improve achievement for everybody have proven elusive. Research on individualization indicates modest results, usually finding that matching style to treatment did not improve achievement. According to Willingham (2005) the most current, rigorous review of literature on the effectiveness of individualization was a meta-analysis conducted by Kavale and Forness (1987). They originally located approximately 250 studies, but only included studies which met the following criteria: (a) modality preference had to have been formally assessed, (b) instructional materials had to be specifically developed to capitalize on modality preference, and (c) the results of instruction had to be measured using a standardized instrument. Based on these selection criteria, 39 studies involving 3,087 students at the elementary and secondary levels were chosen. They concluded the following:

> Although the presumption of matching instructional strategies to individual modality preferences to enhance learning has great intuitive appeal, little empirical support for this proposition was found from the quantitative synthesis of the extant research. Neither modality testing nor modality teaching were shown to be efficacious. (p. 237)

Table 1
Database Search Results for Empirical Journal Articles

Search Type	Cognitive Style	Learning Style	Brain-Based	Multiple Intelligence
Title Contained Term	3445	3299	120	783
Title Contained Term and Abstract Contained "n="	110	132	0	7

Klein (2003) drew identical conclusions in his extensive examination of the learning styles and multiple intelligences literature, as did Coffield et al. (2004), and Willingham (2005). In addition to the lack of effect for matching style with achievement, in some cases learning was superior when the style did not match instruction (e.g., Good, Vollmer, Creek & Katz, 1993). Furthermore, often a particular style does not correspond to the learning tasks/activities that the style would predict a person would choose (e.g., Graham & Kershner, 1996).

Similar to achievement in general, in the key area of reading, Snider's (1992) review of the literature found no evidence that matching style to instruction improves achievement. Similar conclusions were drawn by Stahl and Kuhn (1995). More specifically, they conclude, based on Robinson's (1972) study of 448 beginning readers, that there is no value in identifying children as having auditory vs. visual preferences and subsequently teaching to those preferences:

> Reading is a linguistic process based, at least in English, on alphabetic principles which incorporate both visual and auditory components. The purpose of instruction in beginning reading is to make children aware of that principle. This connection can be facilitated only through the integration of various modalities, not through their separation. (p. 398)

Thus, conceptualizing the evidence in terms of aptitude by treatment interactions, all of the learner profiles presented here predicted interactions –that is certain methods are more effective depending on learner profile—but did not find them. Figure 1 illustrates the adaptation/interaction hypothesis and the empirical evidence.

It is, of course, impossible to prove that something does not exist simply because we cannot find it—that is, one cannot prove the null hypothesis. Fortunately, there is an alternative conception of adapting to individuals that is not only more educationally sound, but is also easier to implement. We turn to this next. But first, we must address the question why, despite the evidence to the contrary, do teachers accept the interaction hypothesis as being valid?

As noted, learning styles are typically determined by having students complete a self-report inventory, and while they are less reliable than achievement tests (Hopkins, 1998, p. 436), many inventories have been shown to have acceptable reliability. Thus, choosing the appropriate inventory is critical in establishing a person's affective traits (Coffield et al., 2004). In practice, however, much of the classroom diagnosis of students' styles is done quite informally without the benefit of independent measures, validated or not. But these diagnoses are often informed by the "common knowledge" that students have such styles and instruction that adapts to their preferred styles is best. Or, as Willingham (2005) phrased the question, "If modality theory [what we are calling the interaction/adaptation hypothesis] is so wrong, why does it feel so right?" (p. 35). He explains,

> For example, a teacher might verbally explain to a student—several times—the idea of "borrowing" in subtraction without success. Then the teacher draws a diagram that more explicitly represents that the "3" in the tens place really represents "30." Suddenly, the concept clicks for the student. The teacher thinks "Aha. He's a visual learner. Once I drew the diagram, he understood." But the more likely explanation is that the diagram would have helped any student because it is a good way to represent a difficult concept.

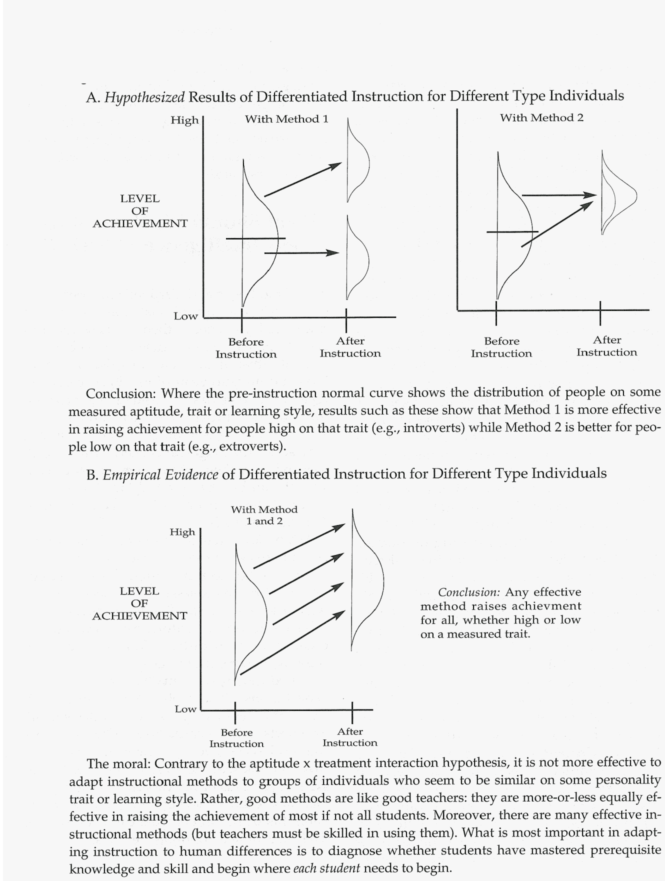
Adapting to Individuals Rather than Individual Differences

There are perhaps two major goals of a sound educational program: (a) to expand students' knowledge, skills, and appreciation vis-à-vis a field of study and (b) to refine or improve the capabilities students come with. To take the second goal first, students who are blessed with good acoustic abilities, high musical intelligence, or so-called right-brain holistic intuition sensitivities should indeed be encouraged to use and perfect those abilities. If mastered to a high level, they provide students with marketable skills or a lifetime of avocational pleasure as linguists, musicians, or counselors. If pursued exclusively, on the other hand, other capabilities—e.g., imagery, logical mathematical intelligence, and left-brain skills—will not develop or will atrophy. As brain research demonstrates, *use it or lose it* (Bruer, 1997). Thus, ironically, when educators identify learners' traits and teach them in the manner in which they are already skilled, they do so at the expense of goal #1. They are limiting rather than expanding the students' repertoires (Felder & Brent, 2005).

The way out of this seeming dilemma is the approach Gardner and his colleagues take with multiple intelligences: they help teachers expand their repertoire of teaching methods. Individualization of instruction, in this view, occurs not by matching a child's intelligence profile to a particular method, but by assuring that throughout the curriculum each student has both the opportunity to capitalize on his or her strengths, while continuing to develop and appreciate other strategies and ways of thinking.

If there are different ways of being intelligent in different domains, then it behooves researchers and

Figure 1
Main vs. Interaction Effects for Instructional methods.



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teachers to explore which teaching methods are most effective in various domains. Research on teaching methods has demonstrated that a variety of methods have been shown to be effective depending on context and subject matter (Lalley & Miller, 2007), so focusing on styles in lieu of subject matter may severely compromise learning (Coffield et al., 2004). In Willingham's (2005) review of what cognitive science has to offer, he argues that "Teachers should focus on the content's best modality—not the student's" because "…*modality matters in the same way for all students*" (p.35, italics in original). We already cited his example of using a diagram to help students visualize place value, but he cites a large and growing amount of evidence that good teaching methods (e.g., using imagery) are effective in general (i.e., they are main effects), not just for students with similar traits (i.e., interaction effects).

Finally, we return to perhaps the most basic issue of all: we adapt to individuals best by starting with each student's prior knowledge. We present several well-established independent but converging lines of reasoning for this argument, all of which paralleled and, at times, pre-date the styles movement: (a) from memory research, (b) from transfer theory, (c) from learned helplessness research, (d) from perceptual/cognitive theory, and (e) from instructional theory.

From a memory perspective, new material (facts or skills) learned to a high standard will nevertheless likely be substantially forgotten within hours or days of initial acquisition. As Ebbinghaus (1885) first demonstrated, however, there is considerable savings (of time) in *relearning* that material, and continued practice past the point of initial mastery - called over learning - improves subsequent recall (see also Postman, 1962a). Under optimal conditions for over learning, such as practice to the point of automaticity (e.g., Schneider & Shiffrin, 1977) or distributed practice and organization of the material, such knowledge may become relatively immune to forgetting (achieving "permastore" in Bahrick's,1984a and b, terminology). Of course, material that is not initially mastered shows few benefits of savings or over learning, but instead elicits reactions from students such as, "We never had this stuff before," despite curricular evidence to the contrary.

From a transfer perspective, the higher the degree of mastery of prerequisite knowledge or skill, the higher the probability of applying that knowledge in new situations (e.g., Jung, 1962; Postman, 1962b). As a century of research beginning with Judd (1908) demonstrates, however, prior knowledge or skill is necessary but not sufficient for transfer. This is so because (a) knowledge and skills are acquired in a specific situation and not easily decontextualized (from situated cognition research; e.g., Brown, Collins & Duguid, 1989), (b) because it is easier to misapply past learnings than it is to recognize which knowledge to apply to a new problem or learning task (from proactive interference research; e.g., Deese & Hulse, 1967; Ellis, 1965), and (c) partially learned material provides students with a false sense of security regarding their knowledge, which is often less complete and more shallow than their "feelings of familiarity" suggest (from feeling of knowing and matacognition research; e.g., Willingham, 2003).

If adequate mastery or partial knowledge does not easily transfer, then little or no mastery virtually guarantees "The Matthew Effect"--that the rich get richer and the poor get poorer. This effect of differences in prior knowledge leads to the well-known "fourth-grade slump," in which children disadvantaged by poor vocabulary and literacy skills fall further behind, not only in reading comprehension scores, but in the capacity to learn more vocabulary and literacy skills by reading (e.g., Chall & Jacobs, 2003; Hirsch, 2003).

The consequences of not mastering consensus societal goals are probably best described from the perspective of learned helplessness research (e.g., Peterson, Maier & Seligman, 1993; Seligman, 1975). When students who initially failed to master material encounter it again, there is no savings advantage in relearning. As noted above, they may even believe "they never had this stuff before," and it does not help that their teachers insist that they had. If on their second attempt they still do not understand, and see themselves as falling further behind those who do, then on subsequent exposures to this material they are likely to say (to their teachers as well as to themselves) "I was never very good at this" or "I could do it if I wanted to, but this stuff is useless" (the former a primarily feminine attribution, the latter primarily masculine; e.g., Dweck & Licht, 1980). Learned helplessness is setting in, producing a kind of proactive interference on cognitive, behavioral and emotional levels for new learning due to uncontrollable failure experiences on similar material in the past. The cure or antidote for learned helplessness is competence on, or mastery of, prerequisites, which can then produce the prior knowledge, motivation to try, and emotional readiness - in a word, self-efficacy (Bandura, 1977; 1986) - to succeed.

From a cognitive perspective, it is fair to say that the field was built on the assumption that each perceptive and cognitive act is an interpretation or construction of new stimulus information in terms of what is already known (e.g., "analysis by synthesis" in Neisser's, 1967, seminal book entitled Cognitive Psychology; see also Miller, Galanter & Pribram, 1960). Encoding, for example, is commonly defined as "the process of categorizing, labeling, or finding meaning in incoming information" (Gentile & Lalley, 2005, p. 607), which is accomplished by comparing the incoming material to what is already in long-term memory. All of this can then be re-organized to go back into memory for future perceptual/cognitive acts. This active, constructive view of cognitive processes is perhaps best illustrated by the corpus of research on experts vs. novices. The evidence shows that relative to novices, experts have more knowledge, better memories, and superior problem-solving ability, but only on tasks related to their expertise (e.g., in chess, see Chase & Simon, 1973; deGroot, 1965, 1966; and Charness, 1976; in music, see Halpern & Bower, 1982; in problem-solving, see Chi, Glaser & Rees, 1982 and Rumelhart & Norman, 1981). Because they have more accessible knowledge than novices, relative experts can encode "larger perceptual chunks" (Chase & Simon, 1973, p.80) from the task at hand and therefore more fully and more quickly understand the task. These studies also show that there is at least one way in which relative experts and novices are exactly the same--namely, they both try to make sense of any new situation on the basis of their prior knowledge.

From an instructional perspective, researchers have long emphasized the importance of adapting to and activating prior knowledge because, as John Holt (1964) phrased it, "To find a man lost in the woods, we have to go where he is" (p. 103). Such concepts as entering behavior (Glaser, 1962, 1984; Glaser & Bassock, 1989), learning hierarchies (Gagne & Paradise, 1961), advance organizers (Ausubel, 1960,1963), and anticipatory sets (Hunter, 1994; see also Gentile, 1993) have generated empirical evidence as well as suggestions for curricular objectives based on activating students' prior knowledge (e.g., Gagne & Driscoll, 1988; Rosenshine & Stevens, 1986; Shuell, 1988, 1996). As any teacher can attest, however, much prerequisite knowledge is not just missing, but incorrect. This implies that proper sequencing must go beyond just curriculum sequencing to correct diagnoses of students' misconceptions and starting there to assure that each student has mastered prerequisites in readiness for subsequent objectives, as in mastery learning (e.g., Block, Efthim & Burns, 1989; Gentile & Lalley, 2003).

Perhaps the most famous - and optimistic - statement of this point was Bruner's (1960; p. 33): that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development." This hypothesis was based on the idea of a true spiral curriculum in which rigorous and relevant instruction on the fundamentals of a field make subsequent learning easier. This, in turn, was based on the Piagetian notion that each learning experience must allow--indeed, require--that learners actively restructure their knowledge or schemata. Only then will they be cognitively and emotionally ready for the next phase or stage. When they are, then the proper spiral curriculum activates relevant prior knowledge in the context of the current instructional objectives and thus has the potential of maximizing transfer and/or higher order understanding of that material.

Implications

The overriding implication based on the inconclusive results for the interaction/adaptation hypothesis and the compelling results from research on prior knowledge, is that effective instruction should be tied to students' prior knowledge rather than students' traits. For example, in the area of earth science, for students to understand the effect of pollution on bodies of fresh water such as the Great Lakes, they must first understand the concepts of pollution and fresh water, particularly the damage done by the former and the value of the latter. If they do not, information about pollution on water will have little value. In the subject of history, for example, students must have a good understanding of day-to-day life in a pre-industrialized society to appreciate the impact of industrialization. Similarly, in physics, students must have a firm grasp of the concept of mass before they can understand its relationship to forces applied by gravity and acceleration.

For teachers to assure that students have sufficient prior knowledge to learn from instruction teachers have two options: (a) assure that every lesson is comprehensive and includes all of its inherent skills and information, or (b) implement the procedure of *formative assessment* (Bloom, Hastings & Madaus, 1971). While the first approach would be overwhelming, inefficient and ineffective, formative assessment is a way to determine what students already know, provide feedback about their knowledge and misconceptions, and provide instruction that is just beyond their current level of understanding (see, for example, Heritage, 2007). Formative assessment can take many forms: quizzes, discussions, games, a one-page paper, etc., any method that will provide teachers with information about students' current level of understanding and allow teachers to adjust teaching accordingly. Formative assessment can be contrasted with *summative assessment*, which occurs at the end of the teaching/learning process and is done with the purpose of determining students' grades (e.g., a final exam).

When using formative assessment, the goal is to determine which students have the least prior knowledge without being in need of remediation beyond the standard scope of classroom instruction. If this seems too low, recall that one inevitable outcome of learning is forgetting. Consider a task that you were once highly competent at but have not done for a while, such as diagramming sentences, doing proofs in geometry, labeling the parts of a frog's digestive system, or explaining how tectonic plates function. It is unlikely that these could be done as well as they once could. The reason: you forgot. The good news is that you can *relearn* such things in much less time than was originally needed, and, each time you relearn something forgetting decreases. So, what is often thought of as wasting successful students' time to benefit those who need more instruction, is actually allowing students in the former group additional practice and improving their likelihood of retention, while the others may be learning critical information for the first time. On the other hand, if there is no formative assessment, the best case scenario is that a teacher runs the risk of teaching only a select group of students in his or her class—so much for "no child left behind" or "all children can learn". Of course, the worst case scenario is that without determining what students know or "finding them in the woods", teaching may be done solely for the sake of teaching and not for the sake of learning.

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Notes

1. Academic Search Premier provides full text for more than 4,600 scholarly publications, including full text for more than 3,500 peer-reviewed journals. Coverage spans virtually every area of academic study and offers information dating as far back as 1975.

2. PsycINFO contains nearly two million citations and summaries of journal articles, book chapters, books and dissertations, all in the field of psychology. Journal coverage, which dates back to the 1800s,

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