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Using Learning Style Instruments to Enhance Student Learning

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ABSTRACT

The emergence of numerous learning style models over the past 25 years has broughtincreasing attention to the idea that students learn in diverse ways and that one approach to teaching does not work for every student or even most students. We have reviewed five learning style instruments (the Kolb Learning Style Indicator, the Gregorc Style Delineator, the Felder–Silverman Index of Learning Styles, the VARK Questionnaire, and the Dunn and Dunn Productivity Environmental Preference Survey) in this article in order to describe the learning style modes or dimensions measured in the instruments; find the common measures and the differences; report on research on instrument validity, reliability, and possible improvement in student performance; suggest classroom activities that work with the different student learning styles; and recommend selection of models under several conditions. We also review one additional learning style instrument, the Revised Approaches to Studying Inventory, as a complementary approach to using one or more of the first five learning style instruments.

Subject Areas: Learning Style Models.

INTRODUCTION

We believe that it is the exception rather than the rule that doctoral programs in thebroadly defined management field provide more than a token effort at educating their doctoral students on adult pedagogy (Merriam & Caffarella, 1999) and philosophy of education (Noddings, 1998). We also believe that most faculty in higher education initially adopt a teaching style that merges (1) the ways they prefer to learn and (2) approaches to teaching they saw as effective for their own learning in their higher education programs. As a result, it is likely that many faculty in higher education are either unfamiliar with learning style models and their potential to inform and enhance the learning processes in the classroom or are uncomfortable experimenting with or utilizing learning styles other than their own preference because it takes them out of their own comfort zone.

Within the last three decades, the proposition that students learn and study in different ways has emerged as a prominent pedagogical issue. Learning styles

(Claxton & Murrell, 1987; Coffield, Moseley, Hall, & Ecclestone, 2004a, 2004b) and learning style models (Gregorc & Ward, 1977; Gregorc, 1979, 1985; Kolb, 1984; Felder & Silverman, 1988; Dunn & Dunn, 1975; Dunn, Dunn, & Price, 1982, 1989; Entwistle & Tait, 1995; Fleming, 2001; Duff, 2004; among numerous others) have offered descriptive typologies that range from relatively fixed student natural dispositions to modifiable preferences for learning and studying.

The implications for faculty are significant in that faculty are likely to reach only some of the students in a given course if they assume that all students learn the same way or that one teaching approach will connect with all students. The apparent conclusion is that faculty who are consciously aware of their students' learning styles as well as their own are in a position to make more informed choices in course material, design, and learning processes to broaden the opportunities for effective learning in their courses. We believe that a use of a variety of teaching and learning approaches has the potential to enhance the learning and performance for a wider range of adult students in a course and to expand the learning approaches with which adult students are comfortable and capable of learning.

In this article, we review five prominent learning style models and one approaches to studying model that have instruments that claim to give faculty and students an indication of an individual's learning style or approaches to studying dispositions and/or preferences. We describe each learning style model; report on research on instrument validity, reliability, and student performance; compare the models to find commonalities and differences; examine possible ways to resolve the differences; recommend selection under several conditions; offer suggestions for classroom activities; and suggest avenues for future research.

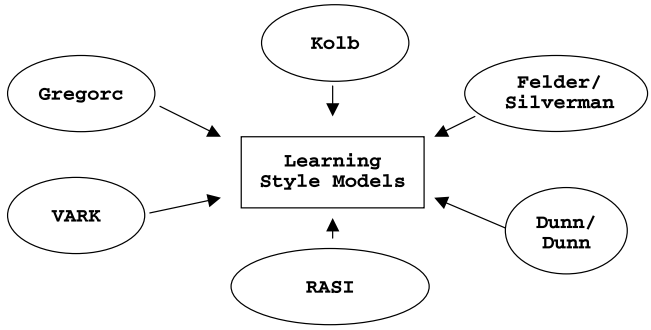
LEARNING STYLE MODELS AND INSTRUMENTS

Learning style is a component of the wider concept of personality. McAdams and Pals (2006) offer a five-principle model of the whole person that encompasses evolutionary design for human nature, dispositional traits, characteristic adaptations, self-defining life narratives, and culture/social contexts. Learning style falls into the categories of dispositional traits and characteristic adaptations where there are differences across individual humans but there are groupings of humans who have common or similar learning style characteristics.

Advocates of learning style models (Claxton & Murrell, 1987; Coffield et al., 2004a, b) postulate that students learn in different ways. Taking that as a basic premise leads to the implications that higher education faculty should not assume (1) that all adult students learn the same way and (2) that a faculty member's own dispositions and/or preferences for learning are broad enough to accommodate the learning needs of most or all the students in the course. Rather, because the premise is that adult students learn in different ways, faculty in higher education would have a responsibility to expand their repertoire of learning activities to embrace as wide a field of adult student learning styles as possible in order to achieve more effective learning.

We will review six well-known and widely available learning style instruments (Figure 1) offered by Kolb, Gregorc, Felder–Silverman, Fleming, and Dunn and Dunn as well as the Entwistle and Tait Revised Approaches to Studying model. In each review, we will describe the learning styles that emerge from each

Figure 1: Six prominent learning style models.



instrument and review the instrument validity, reliability, and student performance research, where available.

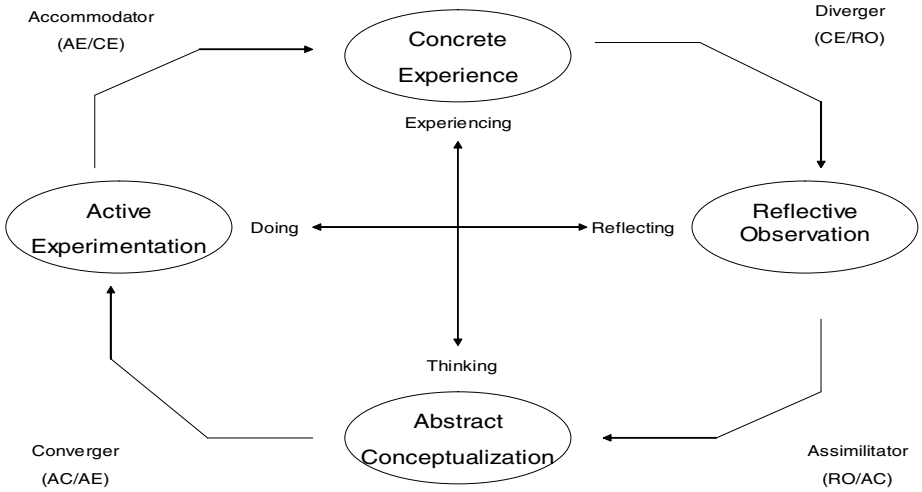
Kolb Experiential Learning Theory

The first model is the Kolb Experiential Learning Theory (Kolb, 1984). This experiential model defines learning as "the process whereby knowledge is created through the transformation of experience" (p. 26). Learning is a holistic set of processes that are continuous, with a lesser emphasis on outcomes. Learning style is the "generalized differences in learning orientation based on the degree to which people emphasize the four modes of the learning process" (p. 76). The model asserts a four-mode or four-process learning cycle that covers and generally starts with Concrete Experience (CE), moving to Reflective Observation (RO), then to Abstract Conceptualization (AC), and finally to Active Experimentation (AE), with the most effective and complete learning taking place when learning activities embrace all four modes. However, depending on the individual's preferences, learning may start at any one of the other modes in the cycle.

Kolb describes CE and AC as bipolar on a continuum and orthogonal to a second bipolar continuum of RO and AE. Individual learning styles result from a combination of two adjacent mode preferences in the experiential learning cycle leading to four basic learning styles: Diverger (CE and RO), Assimilator (RO and AC), Converger (AC and AE), and Accommodator (AE and CE). Individuals have a preference for one of the four learning styles but can and should learn to use the other modes. Figure 2 presents the Kolb Experiential Learning Cycle (adapted from Kolb, 1984).

The Kolb Learning Style Inventory (LSI) is a commercially available questionnaire (www.learningfromexperience.com) with twelve items where respondents rank-order four sentence endings that correspond to the four learning modes. Scores are between 13 and 48. Students and faculty can self-administer, self-score, and self-interpret the LSI. Kolb (1984) found moderate support for the validity of his instrument. There has been extensive research on the validity and reliability of the instrument. Some research (e.g., Sims, Veres, & Shake, 1989; Cornwell & Manfredo, 1994) has raised questions about the validity of the instrument, resulting in revisions to the instrument. Most research, however, has supported both

Figure 2: Kolb experiential learning model.



its validity and reliability (Hickox, 1991; Iliff, 1994; Kayes, 2002). Furthermore, neuroscience research (Zull, 2002; Kolb & Kolb, 2005) supports the whole brain involvement in effective learning through the full Kolb experiential learning cycle.

Divergers have a strong imaginative ability, are good at seeing things from different perspectives, are creative, and work well with people. Assimilators have abilities to create theoretical models, prefer inductive reasoning, and would rather deal with abstract ideas. Convergers have a strong practical orientation, are generally deductive in their thinking, and tend to be unemotional. Accommodators like doing things, are risk takers, are in the here and now, and solve problems intuitively.

Kolb (1984), Svinicki and Dixon (1987), Vince (1998), and Wynd and Bozman (1996) suggest numerous classroom approaches that faculty can use to accommodate the diverse learning modes of their students indicated by the Kolb LSI. Wynd and Bozman (1996) suggest that traditional students generally will prefer starting in the RO/AC quadrant while nontraditional learners will prefer the AC/AE quadrant. Kolb (1984) and Brokaw and Merz (2000) indicate that matching

Table 1: Activities that accommodate Kolb learning processes.

Concrete Experience	Reflective Observation	Abstract Conceptualization	Active Experimentation
Lecture Examples	Thought Questions	Lecture	Lecture Examples
Problem Sets	Brainstorming	Papers	Laboratories
Readings	Discussions	Analogies	Case Studies
Films	Logs	Text Readings	Homework
Simulations	Personal Journals	Projects	Projects
Laboratories		Model Building	Fieldwork
Observations		Model Critiques	
Field work			

Source: Kolb (1984); Svinicki and Dixon (1987).

learning activities with learning style enhances student performance in courses. Table 1 below provides a number of learning activities to support each learning mode.

Gregorc Learning Style Model

The second model is the Gregorc Learning/Teaching Style Model (Gregorc & Ward, 1977; Gregorc, 1979, 1985, 1997; Butler, 1986). This is a model, based in phenomenological research as well as Kolb's experiential learning cycle, that defines learning style as "distinctive and observable behaviors that provide clues about the mediation abilities of individuals and how their minds relate to the world and, therefore, how they learn" (Gregorc, 1979, p. 19). Gregorc claims that individuals have natural predispositions for learning along four bipolar, continuous mind qualities that function as mediators as individuals learn from and act upon their environments. Those mind qualities are abstract and concrete perception, sequential and random ordering, deductive and inductive processing, and separative and associative relationships. The Gregorc Style Delineator (GSD) provides metrics on the first two qualities, perception and ordering, giving an individual a score from 10 to 40 in each of four learning styles of Concrete-Sequential (CS), Abstract-Sequential (AS), Abstract-Random (AR), and Concrete-Random (CR), with a maximum of 100 points for all four. Gregorc describes Concrete and Abstract as orthogonal to Sequential and Random. Although the scores indicate the individual's innate dispositions for one, two, three, or all of the styles, individuals can improve their use of the mind qualities that do not score high. Figure 3 presents the Gregorc Learning Model (adapted from Gregorc, 1985).

The GSD is commercially available (www.gregorc.com) and asks the respondent to rank order ten sets of four words that correspond to the four poles of the two mind qualities. Students and faculty can self-administer, self-score, and self-interpret the GSD. Gregorc (1979, 1985) provides only limited research on the validity and reliability of his instrument. Joniak and Isaksen (1988) and O'Brien (1990) found moderate support for reliability but only partial and limited support for the validity of the GSD.

Figure 3: Gregorc learning style model.

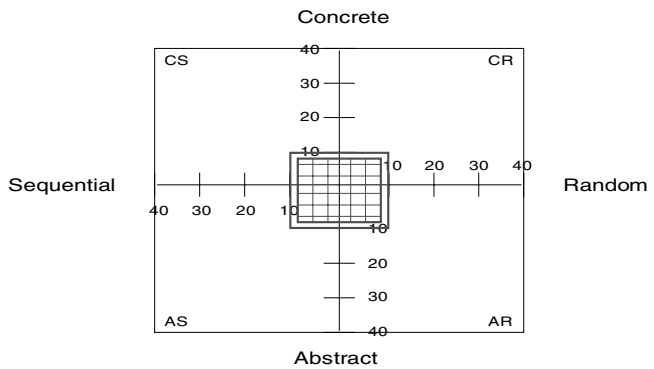


Table 2: Activities that accommodate Gregorc learning styles.

Concrete Sequential	Abstract Sequential	Abstract Random	Concrete Random
Checklists	Lectures	Mapping	Brainstorming
Worksheets	Outlines	Group Work	Creating Possibilities
Outlines	Documenting	Cartoons	Case Studies
Charts	Lengthy Reading	Music	Hands-on Experience
Maps	Audio Tapes	Humor	Mapping
Demonstrations	Writing Reports	Discussion	Optional Reading
Field Trips	Doing Research	Role Play	Simulations
Diagrams	Term Papers	Interviewing	Investigations
Flowcharts	Instructional Media	Keeping Journals	Problem Solving

Source: Butler (1986).

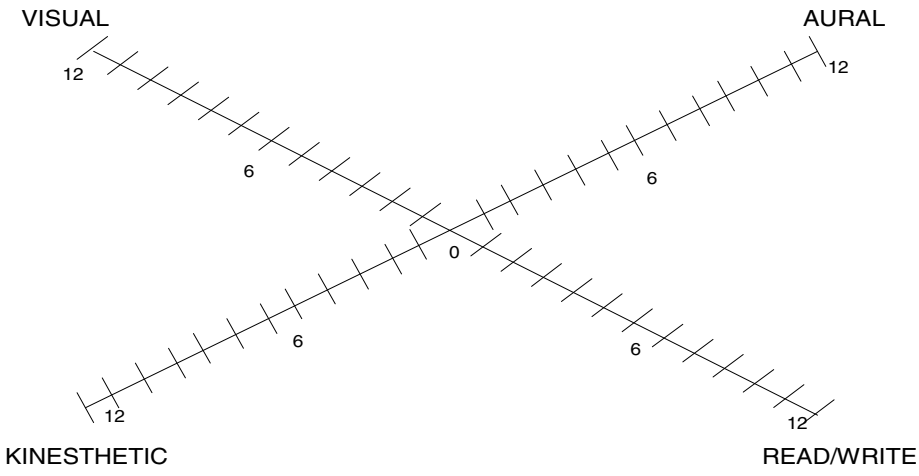
The CS learner prefers direct, hands-on experience, wants order and a logical sequence to tasks, and follows directions well. The AS learner likes working with ideas and symbols, is logical and sequential in thinking, and likes to focus on the task without distractions. The AR learner focuses attention on the people and the surroundings, prefers discussions and conversations that are wide ranging, and wants time to reflect on experiences. The CR learner is experimental and a risk taker, likes to explore unstructured problems, makes intuitive leaps in solving them, and uses trial and error to work out solutions.

Butler (1986) offers an extensive discussion of classroom approaches that accommodate the learning styles revealed through the GSD. The CS learner relates best to the concrete world with hands-on experience, prefers a structured, step-by-step learning process using all of the senses, and wants explicit and clear directions. The AS learner relates best to the world of ideas in a sequential and structured manner, uses the mind to explore, likes well-researched documentation, and is very analytical and evaluative. The AR learner relates best to the world of emotions and the spirit, prefers a nonlinear order that is harmonious, wants personal experiences and supportive relationships, and works for good communication. The CR learner also relates well to the concrete world, prefers a nonlinear order, looks for the big picture, uses experience to investigate, and is intuitive, creative, and a risk taker. Table 2 above provides a number of learning activities to support each learning mode.

The VARK Model

The third model is the VARK Model (Fleming, 2001), a sensory model that is an extension of the earlier neuro-linguistic model (Eicher, 1987). The acronym VARK stands for Visual (V), Aural (A), Read/Write (R), and Kinesthetic (K). Fleming (2001) defines learning style as "an individual's characteristics and preferred ways of gathering, organizing, and thinking about information. VARK is in the category of instructional preference because it deals with perceptual modes. It is focused on the different ways that we take in and give out information" (p. 1). The only perceptual modes, or senses, it does not address are taste and smell. The VARK Inventory provides metrics in each of the four perceptual modes, with individuals having preferences for anywhere from one to all four. Individual students have

Figure 4: VARK learning model.



relative preferences along each of the four perceptual modes but can learn to function in the other modes. Figure 4 presents the VARK model (adapted from Fleming, 2001).

Fleming (2001) reports that about 41% of the population who have taken the instrument online have single style preferences, 27% two preferences, 9% three, and 21% have a preference for all four styles.

The free VARK questionnaire (www.vark-learn.com) offers thirteen statements that describe a situation and asks the respondent to pick one or more of three or four actions that the respondent would take. Each action corresponds with a VARK Learning Style preference. The total of all four scores ranges from 13 to 48, with individuals having a preference for one, two, three, or all four of the learning channels. Students and faculty can self-administer, self-score, and self-interpret the VARK Inventory.

There are also differences in learning approaches for the four VARK Learning Styles. Visual learners prefer maps, charts, graphs, diagrams, brochures, flow charts, highlighters, different colors, pictures, word pictures, and different spatial arrangements. Aural learners like to explain new ideas to others, discuss topics with other students and their teachers, use a tape recorder, attend lectures and discussion groups, and use stories and jokes. Read/Write learners prefer lists, essays, reports, textbooks, definitions, printed handouts, readings, manuals, Web pages, and taking notes. Kinesthetic learners like field trips, trial and error, doing things to understand them, laboratories, recipes and solutions to problems, hands-on approaches, using their senses, and collections of samples. Fleming (2001) offers extensive suggestions for classroom approaches for matching teaching styles and learning styles. Table 3 summarizes a number of learning activities to support each learning style.

Fleming (2001) discusses the validity of the instrument, presenting research that supports the use of the instrument in identifying learning preferences of students. Beyond his reports, there is no other research on validity or reliability.

Table 3: Activities that accommodate VARK learning styles.

Visual	Aural	Read/Write	Kinesthetic
Diagrams	Debates, Arguments	Books, Texts	Real-Life Examples
Graphs	Discussions	Handouts	Examples
Colors	Conversations	Reading	Guest Lecturers
Charts	Audio Tapes	Written Feedback	Demonstrations
Written Texts	Video+Audio	Note Taking	Physical Activity
Different Fonts	Seminars	Essays	Constructing
Spatial Arrangement	Music	Multiple Choice	Role Play
Designs	Drama	Bibliographies	Working Models

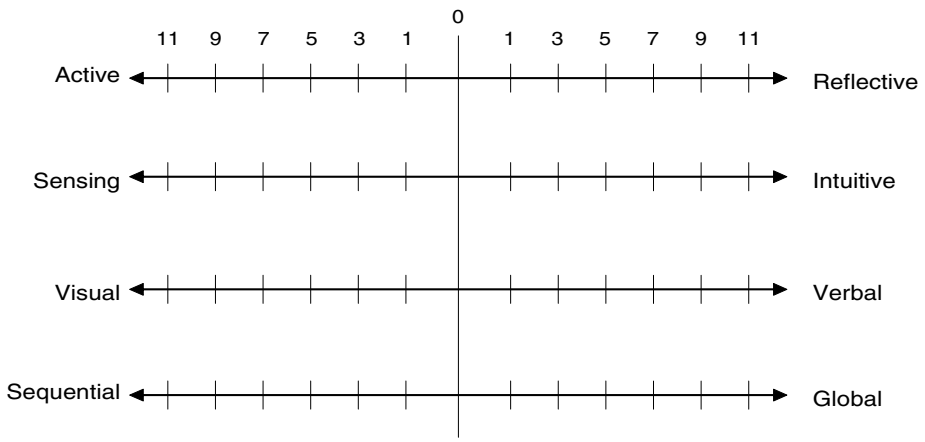
Source: Fleming (2001).

Fleming also presents the results of research that indicate higher student performance in courses when faculty match learning activities with students' learning styles as determined by the VARK instrument.

Felder–Silverman Learning/Teaching Style Model

The fourth model is the Felder–Silverman Learning/Teaching Style Model (Felder & Silverman, 1988). This model, originating in the engineering sciences, defines learning style as "the characteristic strengths and preferences in the ways individuals take in and process information" (Felder & Silverman, 1988, p. 674). It asserts that individuals have preferences along five bipolar continua: the Active-Reflective, the Sensing-Intuitive, the Verbal-Visual, the Sequential-Global, and the Intuitive-Deductive. Figure 5 presents the Felder–Silverman Model (adapted from Felder & Silverman, 1988).

Figure 5: Feldr–Silverman learning style model.



The Index of Learning Styles (ILS) provides metrics for all but the Intuitive-Deductive dimension, with scores showing the strength of an individual's preference for the indicated continuum. Individual students have relative preferences along each of the four but can learn to function in the other direction.

The ILS is a free, 44-item questionnaire (www.ncsu.edu/effective_teaching) that asks the respondent to choose one of two endings to a sentence that focuses on some aspect of learning. Scoring is 1, 3, 5, 7, 9, and 11, with 1 and 3 showing a balance along the continuum, 5 and 7 showing a moderate preference for one end of the continuum, and 9 and 11 a strong preference for one end or the other. The students and faculty can self-administer, self-score, and self-interpret this inventory. Felder clearly states that the model and instrument are still under development. We were unable to find any published research that addresses the validity, reliability, or student performance based on the use of the instrument.

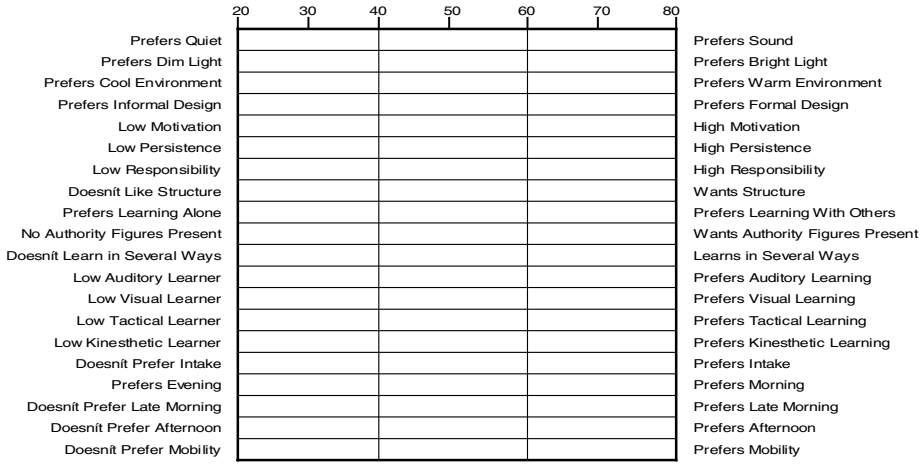
Active learners prefer doing things, particularly in groups. Reflective learners work better on their own, with time to think about the task before doing it. Sensing learners like facts, data, and experimentation and work well with detail. Intuiting learners prefer ideas and theories, particularly when they can grasp new ideas and innovation. Verbal learners like to hear their information and engage in discussion, especially when they can speak and hear their own words. Visual learners like words, pictures, symbols, flow charts, diagrams, and reading books. Sequential learners prefer linear reasoning, step-by-step procedures, and material that comes to them in a steady stream. Global learners are strong integrators and synthesizers, making intuitive discoveries and connections to see the overall system or pattern.

Felder and Silverman (1988) discuss a number of teaching approaches useful to match the learning preferences that emerge from the use of the ILS. Active learners like trying something out, doing it, and seeing if it works, particularly in groups. Reflective learners want to think it through first, take notes in class, and work alone. Sensors like facts, solving problems, working with details, practicality, and real-world connections. Intuitors like discovering possibilities, grasping new concepts, and working with abstractions. Visual learners want to see pictures, diagrams, flow charts, films, and demonstrations. Verbal learners like hearing and discussing information, taping lectures, and explaining themselves. Sequential learners like to move step-by-step through the material, progress logically to the solution to a problem. Global learners want to see the big picture, take in information randomly before putting it all together, and work intuitively.

Dunn and Dunn Learning Style Model

The fifth learning style model is the Dunn and Dunn Learning Style Model as measured by the Productivity Environmental Preference Survey or PEPS (Dunn & Dunn, 1975, 1989; Dunn et al., 1982). Dunn (1990) defines learning style as "the way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information" (p. 353). Dunn and Dunn suggest that there are five learning style stimuli and several elements within each stimulus. The five stimuli and their respective elements are Environmental (sound, light, temperature, and room design), Emotional (motivation, persistence, responsibility, and structure), Sociological (learning alone, in a pair, with peers, with a teacher, and mixed),

Figure 6: Dunn and Dunn Productivity Environment Preference Survey model.



Physiological (perceptual, intake while learning, chronological energy pattern, and mobility needs), and Psychological Processing (global or analytic, hemisphericity, and impulsive or reflective). Figure 6 presents the Dunn and Dunn PEPS model (adapted from Dunn et al., 1982).

Dunn and Dunn's PEPS is a commercially available questionnaire (www.humanresources.com) that offers a set of 100 questions covering all five stimuli and their respective elements. Scores range from 20 to 80, with 40 to 60 reflecting a low or balanced preference for the two ends of each of the 20 elements, and 20 to 40 or 60 to 80 reflecting a stronger preference for the indicated polar end. Students and faculty can self-administer, self-score, and self-interpret the PEPS if purchased online.

Dunn, Griggs, Olson, Beasley, and Gorman (1995) provide an extensive analysis of 42 research pieces about the Dunn and Dunn model that validates the model. Kavale, Hirshoren, and Forness (1998) and Coffield et al. (2004a, b), however, challenge some of the findings in Dunn et al. (1995). Dunn et al. also present research that shows enhanced student performance in courses when faculty match learning activities to student learning style preferences as determined by the PEPS questionnaire.

The Revised Approaches to Studying Inventory

The final model we consider is the Revised Approaches to Studying Inventory model or RASI (Entwistle, Hanley, & Hounsell, 1979; Entwistle & Tait, 1995; Duff, 2004). This model defines learning style as "the composite of characteristic cognitive, affective, and psychological factors that serves as an indicator of how an individual interacts with and responds to the learning environment" (Duff, 2004, p. 56). The model provides scaled measures for individuals on three approaches to studying: deep, surface, and strategic. Students have varying degrees of preferences for the three approaches, with one of the approaches being the most preferred.

The RASI is a 30-question (short form) or 44-question instrument (long form) where students respond with one of five ratings from *strongly agree* to *strongly disagree*. Scores for each of the three approaches to studying range between 10 (the lowest preference) and 50 (the highest preference). The total of the three scores can vary from one student to the next. The short form instrument is available free (http://www.scotcit.ac.uk:8082/resources/pv_rasi.doc), however, there is no scoring available at that site.

Duff (2004) describes students with a preference for a deep approach to studying as individuals who look for meaning in what they are learning and enjoy the learning activity; make connections to previous learning; use logic, reasoning, and evidence well; and examine critically what they have learned and are learning. Students with a surface approach to studying use primarily memorization to learn; have difficulty using logic, reasoning, and evidence; make fewer connections to previous learning; and have difficulty studying. Students with a preference for a strategic approach to studying want to organize their studying routines, manage their time, and learn what is expected to achieve the highest grade possible.

Duff (1997, 2002, 2004) report on extensive research using confirmatory factor analysis that supports the validity and reliability of the RASI.

COMPARISON OF THE FIRST FIVE MODELS

Now that we have introduced and described the learning style models, how do they compare and contrast? Table 4 provides a summary of the learning style definitions. Omitting the RASI because of its approaches to studying focus, Table 5 shows where the first five learning style models have elements in common, if we assume a general commonality of terminology and theoretical comparability.

Table 4: Summary of learning definitions.

Kolb Experiential Learning Model: Generalized differences in learning orientation based on the degree to which people emphasize the four modes of the learning process (Kolb, 1984, p. 76).
Gregorc Learning Style Model: Distinctive and observable behaviors that provide clues about the mediation abilities of individuals and how their minds relate to the world and, therefore, how they learn (Gregorc, 1979, p. 19).
Felder and Silverman Learning Style Model: The characteristic strengths and preferences in the ways individuals take in and process information (Felder & Silverman, 1988, p. 674).
VARK Model: An individual's characteristics and preferred ways of gathering, organizing, and thinking about information. VARK is in the category of instructional preference because it deals with perceptual modes. It is focused on the different ways that we take in and give out information (Fleming, 2001, p. 1).
Dunn and Dunn Model: The way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information (Dunn & Dunn, 1990, p. 353).
RASI Model: The composite of characteristic cognitive, affective, and psychological factors that serves as an indicator of how an individual interacts with and responds to the learning environment (Duff, 2004, p. 56).

Table 5: Learning style composite.

Learning Style Modes	Kolb	Gregorc	Felder–Silverman	VARK	Dunn and Dunn
1.	Concrete Abstract	Concrete Abstract			
2.	Active Reflective		Active Reflective		Impulsive Reflective
3.		Sequential Random	Sequential Global		Analytic Global
4.			Visual Verbal	Visual Aural Read/Write Kinesthetic	Visual Aural Time Kinesthetic
5.			Intuitive Sensing		
6.					Design Sound Light Temperature
7.					Motivation Persistence Responsibility
8.					Self Pair Peers Team Varied

The Kolb and Gregorc Models share the Concrete and Abstract dimensions. The Kolb Model shares the Active and Reflective dimensions with the Felder–Silverman Model and the impulsive and reflective elements of the Psychological stimulus for the Dunn and Dunn Model. The Gregorc, the Felder–Silverman, and the Dunn and Dunn Models have the Sequential and Random/Global dimensions in common. The Felder–Silverman and VARK Models have the Visual and Verbal dimensions in common. And the Dunn and Dunn Model is the only one with the Sociological dimensions. However, there is not a single learning style dimension or element that is common to all five of the models. The Felder–Silverman Model is the only model to contain the Sensing and Intuitive dimensions, the VARK Model is the only model to contain the Read/Write and Kinesthetic dimensions, and the Dunn and Dunn Model is the only one to have the 12 elements in the Environmental, Emotional, and Physiological stimuli and one element in the Psychological stimulus.

A composite of these five models would need to measure the following learning style dimensions:

1. The Concrete and Abstract dimension (Kolb and Gregorc).
2. The Active and Reflective dimensions (Kolb, Felder–Silverman, and Dunn and Dunn).

3. The Sequential and Random/Global dimensions (Gregorc, Felder–Silverman, and Dunn and Dunn).
4. The visual, aural, read/write, and kinesthetic dimensions (Felder–Silverman and VARK).
5. The intuitive and sensing dimensions (Felder–Silverman).
6. The sociological elements of learning through self, pairs, peers, with a teacher, and mixed (Dunn and Dunn).
7. The Environmental elements of sound, light, temperature, and room design (Dunn and Dunn).
8. The Emotional elements of motivation, persistence, responsibility, and structure (Dunn and Dunn).
9. The Physical elements of Perceptual, Intake, Chronology, and Mobility (Dunn and Dunn).
10. The Psychological element of hemisphericity (Dunn and Dunn).

A combination of the Kolb, Felder–Silverman, and the VARK Models or the Gregorc, Felder–Silverman, and VARK would cover the first five. But only the Dunn and Dunn instrument would allow coverage of the last five.

Continuing under the assumptions of general theoretical and term definition comparability of the models, there are further complications in the attempt to find a universal approach. They are (1) the scarcity of research supporting the validity and reliability of the instruments, (2) the cost of purchasing some of the instruments, and (3) the use of class time to administer and interpret the instruments.

There is solid support for instrument validity and reliability for the LSI, PEPS, and RASI instruments, with some support for the VARK. There is moderate support for reliability with the Gregorc LSD but low for its validity. The LSI, VARK, and PEPS would cover all modes of learning except for the Intuitive/Sensing continuum. Use of the RASI would add information on students' preferences for approaches to studying. The missing research supporting instrument validity and reliability would eliminate the Felder–Silverman from consideration.

If cost is not a constraining factor, then the commercially available LSI and PEPS plus the free VARK and RASI would give the most valid and reliable coverage of student learning styles and approaches to studying. On the other hand, if cost is a constraining factor, then use of the VARK, Felder–Silverman, and RASI would yield the most useful information, but information that is suspect from a validity and reliability perspective from the Felder–Silverman.

If use of class time to administer, interpret, and discuss the instruments is a constraint, then the only two Web-based instruments that the students could do on their own time and report the results to the instructor would be the Felder–Silverman and the VARK, with only the VARK having a moderate support for validity and reliability. An advantage for using the Felder–Silverman for students taking courses that fall into the general category of decision sciences and operations research courses would be that the Felder–Silverman is an instrument designed for engineering students.

Up to this point we have made the assumptions that the models have the same general definitions of critical terms and the theoretical comparability. We are not convinced that is the case. As Table 1 shows, each model has its own definition of learning style. The Kolb Model is an experiential model. The Gregorc Model, although emerging out of Kolb's work, is a phenomenological model. The VARK is a sensory/perception model. The Felder–Silverman combines parts of the experiential, the phenomenological, and the sensory. And the Dunn and Dunn PEPS combines elements of all four. The apparent differing theoretical bases for the learning styles suggests the likelihood that it takes differing perspectives to capture the comprehensive character of learning styles, similar to the metaphor of the blind men describing the elephant from differing points of view. The conclusion would be that no one instrument can capture all of the richness of the phenomenon of learning style.

In describing all of the models, we have indicated that students can and should develop their abilities to use the learning styles that are not their natural modes and preferences. Based on that statement, one might argue that faculty, then, should not need to develop a repertoire of learning approaches and processes that embrace the diversity of learning styles in their courses. We would argue otherwise. When we share with the class the anonymous profile of the learning styles of the students in the course, as well as our own learning style information, the students see the diversity of the profile and that not all individuals learn in the same way. When we use differing learning approaches and processes in a course and point them out to our students as to how they match with the differing learning styles, students can see how we are attempting to address their individual needs. When individual students schedule course meetings with us or are struggling to understand an issue in class, knowledge of the student's particular learning style modes and preferences helps us respond to them by choosing explanatory or demonstrative approaches and materials tailored to their learning style preferences. Finally, knowledge of the overall learning style profile of classes allows us to make adjustments to our learning approaches as the profile changes from course to course and across semesters. We believe that student performance improves as a result of our use of the learning style instruments, although we have no empirical data of our own to support that belief.

PROPOSITIONS ON THE USE OF LEARNING STYLE INSTRUMENTS

It is clear from the review of the six learning style models we have presented above that their authors believe using learning style instruments to inform the choice of learning activities and approaches will enhance the effectiveness and quality of learning for students. Our experiences with learning style instruments would reinforce that belief. We would, therefore, offer five propositions.

1. Diagnostic use of one or more learning style instruments and the subsequent use of matching learning activities should result in higher levels of adult student satisfaction with the learning in a course.

2. Diagnostic use of one or more learning style instruments and the subsequent use of matching learning activities should result in higher levels of academic performance by adult students in a course.
3. Diagnostic use of one or more learning style instruments and the subsequent use of matching learning activities should result in deeper, more lasting adult student learning in a course and beyond the course.
4. Diagnostic use of one or more learning style instruments and the subsequent use of matching learning activities should result in an increase in the ability of adult students to learn in different ways in a course and beyond the course.
5. Diagnostic use of two or more learning style instruments and the subsequent use of matching learning activities should result in higher levels of academic performance for the adult students than the diagnostic use of just one learning style instrument.

We have already suggested coupling learning style instruments to extend the diagnostic range available to both faculty and students.

We would also like to draw on our extensive use of the GSD since 1990 to report on the learning style profile of our evening MBA students. Overall, 52% of our students favor the CS style, followed by 20% for CR, 15% for AS, and 12% for AR. There are only small differences between males and females for the first three but 8% of the men and 18% of the women are AR. Because both authors test strongly for the CS and CR styles, we have had more challenges with the AR learners than the others. However, giving extra attention to conversing with AR learners about their difficulties and what would work for them has made it easier to find ways to connect with them.

In the larger picture, keeping in mind that we need to offer alternative and duplicative ways to connect with the differing learning styles pushes us to use differing learning approaches and activities in class as well as when students use office-hour time to clarify issues. Several examples might be useful. We have found that visual learners like to have things written on the board, both as text and as diagrams or flow charts. We reinforce what we put on the board by speaking it out loud so that the aural learners are satisfied. Discussions also help the aural learners. Sequential learners like to work through analyses on a step-by-step basis. However, random or global learners need to see the whole picture before they can see how the steps or parts fit together. So, presenting an example that illustrates the entire process helps them. This includes describing what will happen for the entire semester for the course at the beginning of the course or providing sample articles. Abstract learners like to see a formula and how to connect the formula to the numbers whereas we have found that concrete learners will often bypass the formula and go directly to the numbers, which are concrete to them.

Administration of the learning style instruments should take place as close to the beginning of the semester as possible, preferably during the first class session for purchased and printed instruments. In situations where the faculty member can effectively communicate with the students before the beginning of classes and where Web-based instruments are chosen, faculty should strongly encourage

students to complete the instruments prior to the first class and bring the printed results to class to share with the instructor. Faculty should also take the instruments, share their results and the composite class profile with the students in the course, and discuss the results with the students. And finally, faculty have an opportunity to make a case at their institutions for institution-wide administration and use of learning style instruments and information. This would allow all faculty to ask students to provide the results from taking the learning style instruments.

FUTURE RESEARCH AND RECOMMENDATIONS

We have reviewed and attempted to synthesize only five prominent learning style models and one approaches to studying model in this article. There are other learning style models available. One avenue for future investigation, therefore, would be to expand this review to include other learning style models. Another would be further research on the reliability and validity of the instruments.

We also believe that the contexts in which learning occurs is important. Those contexts are within the institution and outside of the institution (Entwistle, McCune, & Hounsell, 2002). Those two contexts should include the interaction among individuals in the course as well as the interaction of the course and instructor with policies and resources for the program, the department, and the institution, the physical environment, and the historical, cultural, and political background of the country. How do these interact with the individual learning style characteristics to enhance or hinder learning? Individual learning styles are likely to be important but not in isolation of other factors.

In our review of all of the models, we have found that most of the authors have encouraged faculty using learning style information to make an effort to expand the range of learning style capabilities of their students by using a variety of learning activities and supporting their students as they attempt to become more proficient using learning styles in which they have less comfort. Although there are significant grounds for questioning the validity of three of the models we have reviewed here, the models offer commonsense descriptions of many factors that faculty can see at work in the classroom learning environment with their students. Use of one or more learning style instruments should give faculty additional information they can use to craft their learning activities. The use of learning style instruments should allow the students and faculty to consider and seek out more carefully the factors and activities that are conducive to more effective and deeper learning.

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