Why Bother Learning about
Learning Styles and Psychological Types?

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Abstract

A growing body of research suggests that increased learning gains can be achieved with adult learners when instruction is designed with learning styles in mind [1-3]. The adoption of any type of new teaching and/or learning approach has the potential to require a good deal of valuable faculty time and energy. In this paper, the question of why science and engineering faculty should learn about learning styles and psychological types will be addressed. A brief overview of two learning style models and assessment instruments will be presented. These learning style models are: The Dunn and Dunn Model and the Kolb Model. These models will be compared and contrasted in terms of their usefulness and application both inside and outside of the classroom. A comparison will also be made between these learning style models and one well-known application that has been developed to assess psychological type. To this end, the Myers-Briggs Type Indicator (MBTI) will be described.

I. Introduction

Several practitioners within the domains of science and engineering education have noted the importance of embedding a learning style approach within a variety of teaching strategies [4-13]. Still others have looked at applications of psychological (personality) types within these as well as other educational domains [14-18]. In this paper, the research base on learning styles and psychological types will be outlined.

Additional emphasis will be placed on the critical role that these approaches can play in terms of Science, Mathematics, Engineering, and Technology (SMET) education. Specific examples of teaching and learning strategies that utilize these approaches and that have been designed for use in the science and engineering classroom will be shared. Central to each strategy is the fact that when students' individual style and/or type preferences are accommodated, their motivation to learn increases. When students are more motivated to learn, the potential exists for enhanced learning and increased learning gains to occur.

II. What is a *Learning Style*?

Learning style is a biologically and developmentally imposed set of personal characteristics that make the same teaching (and learning) methods effective for some and ineffective for others [19]. Dunn [20] described learning style as the way each learner begins to concentrate, process, and retain new and difficult information. She also highlighted that "To identify and assess a person's learning style it is important to examine each individual's multidimensional characteristics in

order to determine what will most likely trigger each student's concentration, *and* cause long-term memory" (p. 224). To reveal these factors the learning style model must be comprehensive.

Dunn has also offered the following mission statements based on current research on learning styles to assure that every person has the opportunity to learn [21]:

1) Each person is unique, can learn, and has an individual learning style.
2) Individual learning styles should be acknowledged and respected.
3) Learning style is a function of heredity and experience, including strengths and limitations, and develops individually over the life span.
4) Learning style is a combination of affective, cognitive, environmental, and physiological responses that characterize how a person learns.
5) Individual information processing is fundamental to a learning style and can be strengthened over time with intervention.
6) Learning style is a complex construct for which a comprehensive understanding is evolving.
7) Learners are empowered by a knowledge of their own and others' learning styles.
8) Effective curriculum and instruction are learning-style based and personalized to address and honor diversity.
9) Effective teachers continually monitor activities to ensure compatibility of instruction and evaluation with each individual's learning style strengths.
10) Teaching individuals through their learning style strengths improves their achievement, self-esteem, and attitude toward learning.
11) Every individual is entitled to counseling and instruction that responds to his/her style of learning.
12) A viable learning style model must be grounded in theoretical and applied research, periodically evaluated, and adapted to reflect the developing knowledge base.
13) Implementation of learning style practices must adhere to accepted standards of ethics. (p. 1)

Assessing an individual's learning style is vital to the teaching and learning process. An effective match between a student's style and a teacher's style may lead to improved student attitudes and higher student achievement. Many different learning style assessment models and instruments are available. DeBello [22] has indicated that some models are multidimensional, encompassing cognitive, affective, and psychological characteristics, and others are limited to a single variable, most frequently from the cognitive or psychological domain. Some learning style instruments as described by DeBello include those of several theorists including Dunn & Dunn, Hill, Letteri, Ramirez, Reinert, Schmeck, Hunt, Kolb, Gregorc, and McCarthy.

The following sub-sections focus on two learning style models: the Dunn and Dunn Model and the Kolb model. The former is less well known in engineering education, but is the most comprehensive and research-intensive instrument available. The latter is more widely known in engineering education, but offers a limited, but useful assessment of learning style.

The Dunn and Dunn Learning Style Model

This section will focus on the learning style model developed by Dunn and Dunn and the associated learning style assessment instrument developed by Price, Dunn, and Dunn [23]. Price,

Dunn, and Dunn suggested that productivity style theorizes that each individual has a biological and developmental set of learning characteristics that are unique. They further suggested that improvements in productivity and learning will come when instruction is provided in a manner that capitalizes on an individual's learning strengths. As a model, Price, et al. indicated that productivity style embraces several general principles that they state in the form of philosophical assumptions:

1) Most individuals are capable of learning.
2) The learning conditions in which different individuals learn best vary extensively.
3) Individual learning preferences exist and can be measured reliably.
4) Most students are self-motivated to learn when they have the option of using their learning style preferences and experience success.
5) Most teachers can learn to use individual learning styles as a basis for instruction.
6) When selected teachers are not capable of learning to use individuals' learning styles as a basis for instruction, students can be taught to teach themselves and, thus, bypass their teachers' styles.
7) Use of individual learning style strengths as the basis for instruction increases learning and productivity. (pp. 21 -22)

The basic tenet of the Dunns' model is that individual styles must be assessed, and, if a student is to have the best opportunity to learn, instructional techniques must be used that are congruent with each student's style. Not all theorists agree with this tenet because they feel it is extreme. Other theorists wrestle with the question of whether we should teach to an individual's strengths or try to help them develop their weaknesses. The best answer may be both. One of the best ways, especially in large classes, to teach to individual students' strengths is to use a variety of instructional styles and modes of delivery.

The Dunn and Dunn Learning Style Model has had widespread use with adult learners, however its use in engineering and science education has been quite limited. The research conducted by the lead author represents the only published work with the Dunn Model that involves non-science students taking introductory college physics classes. This makes the use of the Dunn Model in engineering and science education even more interesting to study.

The instrument designed to assess the learning/productivity style of adults based on the Dunn and Dunn model is the *Productivity Environmental Preference Survey (PEPS)*. This instrument is one of the most comprehensive learning style assessments that is available. The PEPS is structured as a 100-item, self-report questionnaire rendering a mean score of 50 and a standard deviation of 10. For each of the elements included, a score of one standard deviation above or below the mean indicates an element that makes a difference for that individual. The scoring of the instrument is reported in a PEPS profile having 20 items.

Because three of the 20 items deal with time preference, the instrument is said to assess 18 different elements from five basic stimuli that affect each person's ability to perceive, interact with, and respond to the learning/working environment. These elements are shown in Figure 1.
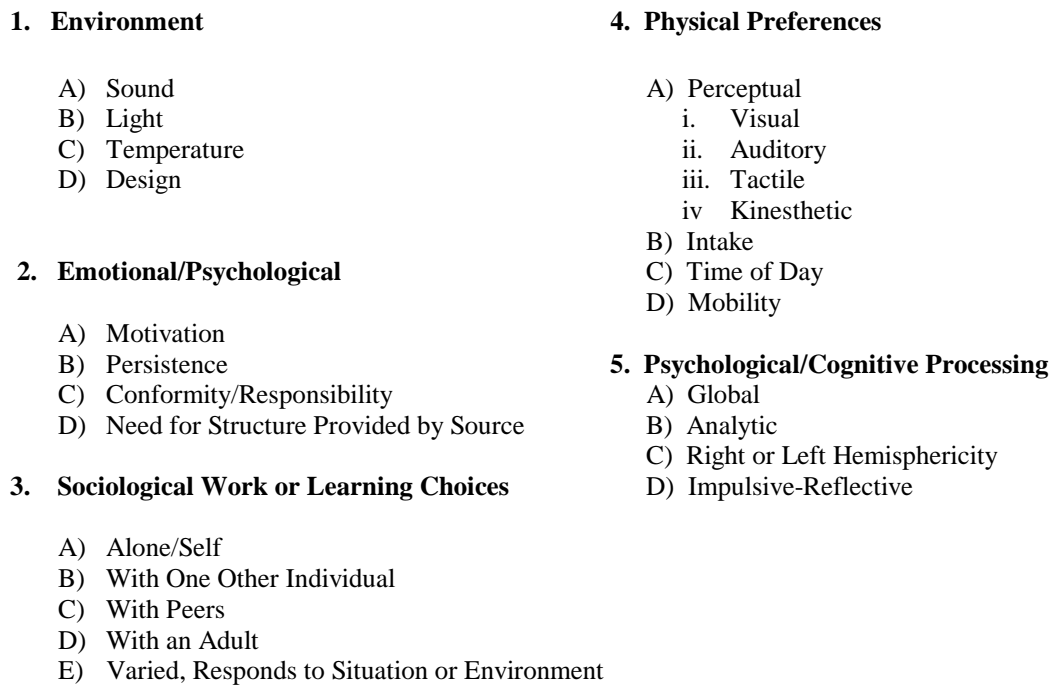
1. **Environment**

   A) Sound
   B) Light
   C) Temperature
   D) Design

2. **Emotional/Psychological**

   A) Motivation
   B) Persistence
   C) Conformity/Responsibility
   D) Need for Structure Provided by Source

3. **Sociological Work or Learning Choices**

   A) Alone/Self
   B) With One Other Individual
   C) With Peers
   D) With an Adult
   E) Varied, Responds to Situation or Environment

4. **Physical Preferences**

   A) Perceptual
      i.   Visual
      ii. Auditory
      iii. Tactile
      iv   Kinesthetic
   B) Intake
   C) Time of Day
   D) Mobility

5. **Psychological/Cognitive Processing**
   A) Global
   B) Analytic
   C) Right or Left Hemisphericity
   D) Impulsive-Reflective

Figure 1. Dunn and Dunn Learning Style Elements

Numerous research studies [24] have documented the reliability and validity of the PEPS. Dunn and Dunn [25] posited that research on their model is more extensive and more thorough than research on many educational topics. As of 1998, research utilizing the Dunn and Dunn Model had been conducted at more than 112 institutions of higher education, at all levels K – college, and with students at most levels of academic proficiency, including gifted, average, underachieving, at-risk, dropout, special education, vocational, and industrial art populations.

Dunn, et al. [26] performed a meta-analysis of the Dunn and Dunn Model of learning style preferences. They reviewed forty-two different experimental studies conducted with the model between 1989 and 1990. Their results indicated that overall academic achievement of students whose learning styles have been matched can be expected to be about three-fourths of a standard deviation higher than those students whose learning styles have not been accommodated. Further, when instruction is compatible with students' learning style preferences, the overall learning process is enhanced.

The Kolb Learning Style Model

David Kolb, a cognitive theorist, developed the *Learning Style Inventory* (LSI) in 1976 [27]. The LSI is a 12-item self-report questionnaire in which each item has four different words/choices. These words/choices are used to describe one's style and are rank-ordered. One word in each item was used to correspond to one of four learning modes [28]. Within the Kolb Learning Style Model, four learning modes are identified: This model has two different pairs of opposite

preferences. The model suggests that individuals have two methods of processing the material either:

(1) *Active Experimentation* (AE - doing),. or
(2) *Reflective Observation* (RO - watching).

Within this pair, individuals tend to prefer one processing method more than the other, and they tend to use that method often since it comes most easily to them. The model further suggests that individuals also have two methods of perceiving or taking in material either:

(3) *Concrete Experience* (CE - feeling), or
(4) *Abstract Conceptualization* (AC - thinking).

Within this pair, individuals tend to prefer one mode over the other, and they tend to use that mode often since it comes most easily to them. The *Active Experimentation* mode describes individuals who take an active role in influencing others as well as situations. These individuals welcome practical applications rather than reflective understanding as well as actively participating rather than observing. The *Reflective Observation* mode describes people who would rather watch and observe others rather than be active participants. Individuals in this mode tend to appreciate exposure to differing points of view. The *Concrete Experience* mode describes people who feel more than they think. Individuals in this mode tend to be very good at relating to others and they tend to be intuitive decision-makers. Finally, the *Abstract Conceptualization* mode describes people who think more than they feel. Such people tend to have a scientific approach to problem solving as opposed to a more artistic approach.
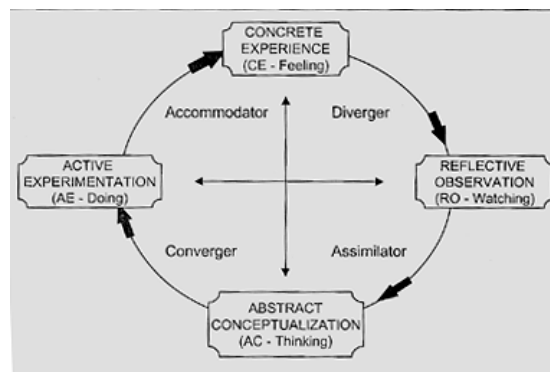

Figure 2. Kolb's Learning Style Model

Thus, this model is a two-dimensional (x-y plot) approach that classifies learning along two axes. The first line measures the way individuals perceive information, with one extreme being concrete experience (Feeling) and the other being abstract conceptualization (Thinking). This is a measure of how an individual takes in information. The second line represents how individuals processes or internalizes information, with one extreme *Active Experimentation* (Doing) and the other *Reflective Observation* (Watching). The two lines form the four statistically prevalent learning styles [29], with each one corresponding to one of the four quadrants on the x-y plot. These styles are referred to as the *Diverger*, the *Assimilator*, the *Converger*, and the *Accommodator.* These styles can also be described as Type I, Type II, Type III, and Type IV,

respectively [30]. Figure 2 (previous page) shows that these styles (or types) can be graphed on a coordinated grid illustrating the bipolar dimensions of processing - *doing* (active experimentation) versus *watching* (reflective observation) on the x-coordinate, and perceiving - *feeling* (concrete experience) versus *thinking* (abstract conceptualization) on the y-coordinate [31].

What follows is a detailed summary of each of the learning style types illustrated in the Kolb Learning Style Model:

1) The *Diverger* (Type I)

The *Diverger's* dominant learning characteristics involve the perception of information through *Concrete Experience*. Information is then processed through *Reflective Observation*. While perceiving information, Divergers need to express their feelings, seek personal meaning as they learn, and desire personal interaction with the instructors as well as other students. A characteristic question of this learning type is "WHY?"

Divergers tend to excel in their ability to view concrete situations from a variety of perspectives and to combine relationships into a meaningful whole. Divergers are "people persons" who are imaginative and emotional. These individuals often benefit from individual counseling and tutoring that has been integrated within their coursework and assignments. Divergers learn well through discussion and are concerned with how information affects people. Divergers also work to keep group discussions and activities harmonious. Individuals with this learning type are called *Divergers* because they can see things from different perspectives and can easily generate ideas. Thus, they excel at brainstorming. To be effective with Type I students, instructors should function as a motivator. Divergers need to be given a reason as to why the material is important to them personally and/or to others with whom they can identify or feel empathy. Effective teaching strategies should involve techniques designed to motivate these individuals and to show them how the course material relates to their personal experiences, their interests, their future careers as well as how it fits into the big picture. Divergers want to interact personally with the instructor and to be recognized as individuals.

2) The *Assimilator* (Type II)

The *Assimilator's* dominant learning characteristics involve the perception of information through *Abstract Conceptualization*. Information is then processed through *Reflective Observation*. Assimilators like to listen to lectures and prefer that the instructor present course material in an organized and accurate manner. Assimilators benefit if they have time for the reflection. A characteristic question of this learning type is "WHAT?"

Assimilators are less interested in people and more interested in abstract concepts. Assimilators are very good at synthesizing disparate observations into integrated explanations and excel when information is detailed, logical, and orderly. They are called *Assimilators* because they take separate pieces of information, analyze them, organize them, and assimilate them into a whole. They like order, tend to be detail-oriented, and thrive on procedures, following directions to the letter. In their approach, they are careful, methodical, and cautious, trying to avoid errors. These individuals like information simply for information's sake, want to know what the experts

think, and seek a conceptual understanding of what they are learning. They do well in traditional school settings.

Interestingly, most students, regardless of their learning style preference, must often function in the assimilator mode to succeed in school. Assimilators also learn well from reading about the topic and do not prefer group work. They will work in a group environment when the are told to do so, however, because they tend to be structured and want to follow established rules procedures. To be most effective with Type II learners, teaching strategies should involve the instructor functioning as the expert.

3) The *Converger* (Type III)

The *Converger's* dominant learning characteristics involve perception of information through *Abstract Conceptualization*. Information is processed through *Active Experimentation*. Convergers tend to respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to fail safely. These individuals like to test information, to try things, to take things apart, to see how things work, and to learn by doing. Convergers seem to do best when there is a single correct answer to a problem or question. A characteristic question of this learning type is "HOW?"

Convergers like to see the practicality and usefulness of the information. These individuals tend to be less emotional and they emphasize getting things done without wasting time. Thus, they do not favor sitting for long periods of time in lecture or reading a great deal of material, since it is their perception they are wasting time. Convergers also tend to prefer to work with things and not people because they tend to see either group work or discussion as a waste of time since they can get work done more quickly individually. Thus, in general they tend to converge or move quickly to make decisions, to seek one correct answer, and to quickly cut through to the essentials of the matter at hand (cut to the chase type of people). The most effective teaching approach for these learners involves the instructor functioning as a coach, and hence, providing guided practice and feedback. Lab settings provide a motivating learning environment for the Type III learner. The concept of mastery learning works well with this group.

4) The *Accommodator* (Type IV)

The *Accommodator's* dominant learning characteristics involve perception of information through *Concrete Experience*. Information is processed through *Active Experimentation*. Accommodators enjoy interacting with others through group activities and discussions, yet can sometimes be viewed as being impatient. In addition, accommodators like to follow their own timetable and order when learning and resent too many procedures and rules. Type IV learners are problem solvers and risk takers, typically learning from their mistakes. These learners can be referred *to as Accommodators* because they take what they have learned and adapt it for their own uses, using their creativity to change it and make it better. A characteristic question of this learning type is "WHAT IF?"

Accommodators like applying course material in new situations to solve real problems. Accommodators are intuitive and tend to do well in situations that call for adaptation to specific

immediate circumstances. These learners thrive when the instructor encourages self-discovery.
To be effective for these learners, the teaching strategies should facilitate the maximization of
opportunities for student to discover things for themselves. Accommodators prefer some
interaction with, but little supervision from, the instructor. Accommodators prefer to have the
instructor stay in the background, to serve as a resource, and to evaluate what they have done.

Table 1 highlights the four quadrants of the Kolb Learning Cycle. Each quadrant contains a
summary of the characteristics typical of each learning type.

Table 1. The 4 Quadrants of the Kolb Learning Cycle - Learner Characteristics.

Accommodators (Type IV) WHAT IF?	Divergers (Type I) WHY?
- Likes problem solving. - Enjoys taking risks. - Prefers to learn through exploration. - Can synthesize information easily. - Self-discoverers. - Brainstorming (especially in groups). - Creators of new things. - Formulators (of many problem types). - Users of information to solve problems. - Communicators of concepts to others.	- Big picture people. - Relies on feelings. - Prefers personal interaction. - Learns by discussion (likes group work). - Sharers (especially spontaneous thoughts). - Good at generating ideas and alternatives. - Brainstorming. - Enjoys peer reviews. - Uses emotion when making decisions.
Convergers (Type III) HOW?	Assimilators (Type II) WHAT?
- Quickly cuts to the chase. - Doesn't like to waste time. - Likes to discover, test, and try new things. - Likes to take things apart and see how they works. - Learns by doing (labs work well). - Does not like lectures. - Quick to make decisions. - Searches for one correct answer. - Does not prefer group work.	- Comprehension is critical. - Strength in analyzing, organizing, and sorting. - Likes to evaluate pros and cons. - Likes information for information's sake. - Enjoys lectures. - Likes synthesizing parts (doing research). - Likes order. - Works to avoid errors using lists to retrieve ideas and information. - Uses logical and detailed thinking. - Does not prefer group work.

An important premise of this learning style model is that everyone, regardless of their preferred
learning style, uses all four learning style types at some point during the learning process. When
a new concept is presented to a student, they must follow the Learning Cycle. The Learning
Cycle starts in quadrant 1 where the student asks "WHY does that happen that way?" to "WHAT
rules, polices or laws do I need to know?", to "HOW do all these parts fit together" to "WHAT
results will I get IF I change this variable?" The instructor's role in the learning process becomes
less and less dominant while the student's role becomes more prominent as you move around the
cycle.

In the following section the concept of psychological type is briefly introduced and described.
This is followed by a somewhat more detailed summary of the Myers-Briggs Type Indicator
(MBTI) which is the most widely known instrument used to assess psychological (personality)

types. The discussion of the MBTI is followed by a contrast and comparison between learning styles and psychological types.

III.   What is a *Psychological Type*?

This section presents a summary of psychological (personality) type. The most well-known instrument used to assess psychological type is the Myers-Briggs Type Indicator (MBTI) [33]. The MBTI was developed by Isabel Myers and is based on the theories of Carl Jung [34]. The MBTI is used to understand personality differences and basically describes various behavior patterns. These behavior patterns in turn affect how we function in the world. This system of understanding different patters of behavior is grounded in the idea that people are unique individuals and are born with "preferences." The word "preference" refers to the ways in which individuals naturally "prefer" to do certain things [35].

Jung's theory of psychological type assumes that what might be considered random behavior is actually very consistent and orderly [36]. The orderliness results, in part, from the way people perceive, interpret, and process information. What follows is a brief summary of the MBTI.

The Myers-Briggs Type Indicator (MBTI)

The model developed by Myers-Briggs classifies students according to their preferences on scales derived from psychologist Carl Jung's theory of psychological types. This model lists four different pairs of opposite preferences. The model suggests that within each pair, individuals tend to prefer one side more than the other, and they tend to use that side the most since it comes most easily to them. The four pairs of opposite preferences are highlighted below:

1. **EXTRAVERT/INTROVERT** - This pair refers to what tends to energizes us and causes us to focus our attention (i.e. a measure of the attitudes toward the flow of mental energy).

EXTRAVERTS (E) - try things out, focus on the outer world of people, or
INTROVERTS (I) - think things through, focus on the inner world of ideas and impressions;

It is important to note an important distinction between introverts and extraverts. For the extraverts, their dominant process (i.e. being extraverted) is very visible, to the point of being conspicuous. Therefore, the extravert's best process tends to be very apparent, even in casual contacts. One can think of extraverts as being interactive. To be effective, the teaching and learning strategies should facilitate trial and error opportunities and to allow the extravert to discover things for themselves. The learning activities should be action-oriented. The extravert responds to a change in environment and can become impatient with long tasks that require depth of concentration.

With introverts, the opposite is true. This relates to the shear essence of what it means to be introverted. When introverts need to focus their attention on the outer world, they tend to use their secondary or auxiliary process to deal with the situation at hand. There are not too many people who are actually allowed into an introvert's inner world. One can think of introverts as being introspective. Myers and Myers [37] suggest that "A cardinal precaution in dealing with introverts, therefore, is not to assume, just from ordinary contact, that they have revealed what

really matters to them" (p. 14). To be effective for the introvert, the teaching and learning strategies should facilitate in-depth introspective opportunities for the students. The introvert will typically ignore a change in environment and will want to contemplate before taking action. Obviously, to satisfy both preferences the instructor should use a variety of instructional styles and modes of delivery.

2. SENSORS/FEELERS - This pair refers to how we prefer to perceive or take in information.

SENSORS (S) - practical detail-oriented, focus on concrete information, facts and procedures gained from their senses, or
INTUITORS (N) - imaginative, concept-oriented, focus on meanings and future, with a view towards patterns and possibilities;

This pair measures the way an individual perceives information. One method of perceiving information is the process of sensing, by which an individual becomes aware of things through his/her five senses. The other is the process of intuition, which is an indirect perception by way of the unconscious. The unconscious contributions take on the form of "hunches". People perceive through their senses, and they also perceive things that are not and have never been present to their senses.

Sensors are so interested in facts that they have little attention to spare for extraneous ideas. The Sensor likes hands-on projects and drill-and- practice problems so long as they do not become too complex. Sensors also like to learn the specific rather then the general. Thus, to be effective for the Sensor, the teaching and learning strategies should include hands-on experiments and sample solutions and homework problems that have only one best answer.

Intuitors are so engrossed in pursuing the possibilities that come to mind when presented with information that they seldom look very intently at only the facts. The Intuitor likes innovation and complexity, and quickly becomes bored with routine drill and practice. To be effective for the Intuitor, teaching and learning strategies should include open-ended essay or design problems that will allow the learner to use their creativity in order to view the general theory.

3. THINKERS/FEELERS - This pair refers to how we evaluate and process information and then make decisions.

THINKERS (T) - skeptical, tend to make decisions based on logic, rules and on objective analysis of cause and effect, or
FEELERS (F) - appreciative, tend to make decisions based on values, personal and humanistic considerations, and subjective evaluation of person-centered concerns;

A basic difference in judgment arises from the existence of two distinct and sharply contrasting ways of coming to conclusions. The first is through the use of thinking; that is, by a logical process aimed at an impersonal finding. The second is by feeling; that is, by placing a personal subjective value on whatever it is you're trying to decide between.

A Thinker will consider first whether their decision is consistent and logical, whereas a Feeler will make a decision based on whether the idea is pleasing or displeasing. To be effective for the

Thinker, the teaching and learning strategies should involve experiments or problems that require some form of logic in the solution process. Cause-and-effect reasoning also work well for this type of processor. In addition, the instructor can be free with their constructive comments and criticisms as the Thinker will not take them personally.

It is, however, important that an instructor be very sensitive to Feelers, because they get frustrated by cause-and-effect reasoning problems and take any type of criticism personally. To be effective for the Feeler, the teaching and learning strategies should include assignments that involve personal contact between the instructor and the student or between students.

4. JUDGERS/PERCEIVERS - This pair refers to our orientation towards life.

JUDGERS (J) - set and follow agendas, planned and organized approach to life and prefer to have things settled, seek closure even with incomplete data, or
PERCEIVERS (P) - adapt to changing circumstances, flexible and spontaneous resist closure to obtain more data.

In order to come to a conclusion, Judgers will momentarily shut off further intake of information. When a Judger is ready to make a decision, they feel all the evidence is in and anymore information is irrelevant and immaterial. When a Judger is ready to make a decision, a Judger makes a decision. A Judger likes order, sets long-term goals, likes to follow schedules and focuses on results. To be effective for the Judger, the teaching strategies should include a detailed course syllabus including dates for tests and homework, and, the instructor should make every attempt to follow that schedule.

A Perceiver shuts off judgment. A Perceiver tends to feel that no matter how much information they are presented with, they don't have enough, and new developments might occur, thus, making it much "too soon" to make a decision. The Perceiver likes to be flexible and they need someone to help them set their schedule. Perceivers tend to focus on the process instead of the results. Thus, many of the strategies used to help the Judger will also help the Perceiver.

These preferences can be combined to form 16 different "types" that involve a combination of these preferences (EI, SN, TF, and JP). By taking one preference from each pair, a four-letter code is established that defines an individual's personality type. For example, one student may be an ESTP (extravert, sensor, thinker, perceiver) while another an INFJ (introvert, intuitor, feeler, judger). The MBTI style types are further summarized in the tables that follow:

Table 2. Sensing Types/Introverts

ISTJ	ISTP
• Serious, quiet, earn success through concentration, thoroughness, and organization.. • Practical, orderly, matter-of-fact, logical, realistic, responsible, and dependable. • Can make up their own minds as to what should be accomplished and work towards it steadily, regardless of protests or distractions	• Cool onlookers - quiet and reserved. • Observe and analyze life with detached curiosity and unexpected flashes of original humor. • Usually interested in cause and effect, how and why mechanical things work, and in organizing facts using logical principles. • Excel at getting to the core of a practical problem and at finding the solution.
ISFJ	**ISFP**
• Quiet, friendly, responsible, and conscientious. • Work devotedly to meet their obligations. • Lend stability to any group or projects. • Thorough, patient, and painstakingly accurate. • Interests are usually not technical. • Loyal, considerate, perceptive, and concerned with how other people feel.	• Retiring, quietly friendly, sensitive, kind, and modest about their abilities. • Shun disagreements and do not force their opinions or values on others. • Usually do not care to lead but are loyal followers. • Often relaxed about getting things done because they enjoy the present moment and do not want to spoil it by undue haste or exertion.

Table 3. Sensing Types/Extraverts

ESTJ	ESTP
• Practical, realistic, matter-of-fact with a natural head for business or mechanics. • Not interested in abstract theories and want learning to have direct and immediate application. • Like to organize and run activities. • Often make good administrators, are decisive and quickly move to implement decisions. • Good with routine details.	• Good at on-the-spot problem solving. • Like action and enjoy whatever comes along. • Tend to like mechanical things. • Adaptable, tolerant, pragmatic, and focused on getting results. • Dislike long explanations. • Are best with real things that can be worked, handled, taken apart, or put together.
ESFJ	**ESFP**
• Warm-hearted, talkative, popular, conscientious, born cooperators and committee members. • Need harmony and may be good at creating it. • Always doing something nice for someone. • Work best with encouragement and praise. • Main interest is in things that directly and visibly affect peoples' lives.	• Outgoing, accepting, friendly, enjoy everything, and make things more fun for others through their enjoyment. • Like action and making things happen. • Know what's going on and join in eagerly. • Find remembering facts easier than mastering theories. • Are best in situations that needs sound common sense and practical ability.

Table 4. Intuitive Types/Introverts

INFJ	INFP
• Succeed by perseverance, originality, and the desire to do whatever is needed or wanted. • Put their best efforts into their work. • Quietly forceful, conscientious, and concerned for others. • Respected for their firm principles. • Likely to be honored and followed for their clear visions as to how best to serve the common good.	• Quiet observers, idealistic, and loyal. • Important that outer life is congruent with inner values. • Curious, quick to see possibilities, and often serve as catalysts to implement ideas. • Adaptable, flexible, and accepting unless a value is threatened. • Want to understand people and ways of fulfilling human potential. • Little concern with material possessions.
INTJ	INTP
• Original and have great drive for their own ideas and purposes. • Have long-range vision and quickly find meaningful patterns in external events. • Have a fine power to organize a job and carry it through, especially in areas that appeal to them. • Skeptical, critical, independent, determined, and set high standards.	• Quiet and reserved. • Especially enjoy theoretical or scientific pursuits. • Like solving problems with logic and analysis. • Interested mainly in ideas, with little concern for parties or small talk. • Have sharply defined interests.

Table 5. Intuitive Types/Extraverts

ENFJ	ENFP
• Responsive and responsible. • Feel real concern for what others think or want. • Can present a proposal or lead a group discussion with ease and tact. • Sociable, popular, sympathetic. • Responsive to praise and criticism. • Like to help enable others to achieve their potential.	• Warmly enthusiastic, highly spirited, ingenious, and imaginative. • Able to do almost anything that interests them. • Quick with a solution for any difficulty and ready to help with a problem. • Often rely on their ability to improvise instead of preparing in advance. • Can usually find compelling reasons for whatever they want.
ENTJ	ENTP
• Frank, decisive, and typically leaders in activities. • Develop and implement comprehensive systems to solve organizational problems. • Good at anything that requires reasoning and intelligent talk, such as public speaking. • Are usually well-informed and enjoy adding to their fund of knowledge.	• Quick, ingenious, and good at many things. • Provide stimulating company, and are alert and outspoken. • May argue for fun or on either side of a question. • Resourceful in solving new and challenging problems, but may neglect routine assignments. • Apt to turn to one new interest after another. • Skillful in finding logical reasons for whatever they want.

Within each pair of preferences, an individual will tend to lean towards one or the other. This tendency to prefer one or the other, does not mean that an individual can't do the other. In essence, an individual's tendency is just that, a tendency. However, the preferred tendency should not be considered mutually exclusive.

At this point, learning style and personality type have been described and defined. In addition, some well-known instruments used to assess style and type have been described. What follows is a brief contrast and comparison between learning style and psychological type.

IV.   *Learning Style* and *Psychological Type*: A Contrast and Comparison

Certainly the instruments used to assess learning style and personality type that have been described in this paper are very different. For example, the Kolb model is a two dimensional (x-y plot) approach that classifies learning along two axes. The first line measures the way individuals perceive information, and the other represents how individuals process information. Thus, Kolb classifies the learning preferences using a 4-quadrant approach. The instrument developed by Myers-Briggs classifies students according to four different pairs of opposite preferences. Like the Kolb, the MBTI measures the way an individual perceives and processes information. However, the methods used in both of these instruments to define and measure perception and processing differs as previously discussed. In addition, the model developed by Myers-Briggs includes the elements of how people focus on and interact with the outer world. The result is a four-dimensional model that classifies learning into 16 different types. The Dunn and Dunn model utilizes 18 different elements within five different stimuli as was illustrated in Figure 1. Like the other two models, the Dunn and Dunn model also measures the way individuals perceive and process information, however, it uses a different definition and procedure to measure these elements. Dunn and Dunn like the Myers-Briggs also measures how people interact with the outside world, although the method is different. Unlike the other two models, Dunn and Dunn does not try and define a style definition for each of the 324 different possible combinations of the 18 preferences, but instead takes a more global look at each student.

Although the instruments used with each model differ, they share the basic idea of using a linear continuum representation to measure the different pairs of opposite preferences. All the models suggest that within each pair, individuals tend to lie somewhere on this continuum, thus, they prefer one side more than the other, and they tend to use that side the most since it comes most easily to them. All three of the instruments also measure the way a student perceives and processes that information. The last two models also measure the way people interact with the outer world.

Regardless of the noted differences, however, we feel there is one strong, common thread that ties these measurement tools together. The common thread is centered around the idea that all individuals, no matter what their learning styles or personality types, CAN learn. The models and associated learning theories may differ in the way they measure a preference, but they all appear to overlap at this same point.

For example, everyone uses all four of the pairs of opposite preferences highlighted in the MBTI, and not solely the ones that are preferred. There is no documented evidence that any set of

preferences is superior to another in any way. In this sense, the theory of psychological type and learning styles mesh nicely since there no evidence exists that would suggest that one learning style is academically superior to another. All types and styles are simply "unique." Certainly one type or style might work best in a particular learning situation, but that doesn't make that style or type superior to another. For example, the authors have been assessing students' styles and types in their classrooms for years, and in every class there are always students representing all four of the quadrant of the Kolb, every personality type of the MBTI, and across the complete spectrum of the Dunn and Dunn. The message here is that each student is unique!

Furthermore, it is important to note the fact that when dealing with the models of personality type and learning styles, the combination of preferences is considered to be greater than the sum of its individual parts. Each part interacts in a variety of ways and to varying degrees. The underlying theme is that each person is a unique individual. Thus the use of the MBTI, or any of the learning style assessment instruments described in this paper, should not be used to "black box" an individual or to plot their "type" or "style" on some type of scale, continuum, or grid.

In terms of scales used to measure style and type, the PEPS learning style instrument (based on the Dunn and Dunn Model) uses a linear scale in which an individual's preferences can lie anywhere on a continuum. The PEPS is the most comprehensive and multi-dimensional instrument currently available to assess learning styles. In addition, more research has been conducted at all age levels with the PEPS than with any other instrument.

The Kolb learning style instrument is certainly a start, but it is much more limited because it essentially measures only two elements. The advantage of the Kolb instrument is that it can be self-scored and students can essentially receive immediate feedback. With the PEPS instrument, a nominal fee is assessed to process the learning style profiles (approximately $1/student) and feedback is not immediate. The MBTI looks at different elements and provides a reasonably comprehensive picture of an individual's personality type preferences.

V.   So - Why Bother Learning about *Learning Style* and *Psychological Type?*

We have now reached a point where we can respond to the question "Why bother learning about learning style and psychological type?" Learning about style and type is important for a number of reasons, regardless of whether we are working with populations of future scientists or engineers, or whether we are working with non-majors. Furthermore, an emphasis on style or type in the classroom helps to open many doors that may lead to enhanced understanding for students.

It has been our experience that a focus on learning style or personality type in the classroom sends students the message that they are cared about and respected as individuals. This message, simple as it may seem, has many broad and far-reaching implications. The most prominent implication is that when students feel valued as individuals, their sense of their self-worth and ability increases dramatically. This increase in individual perceptions of worth and ability, in turn may lead to increased motivation towards learning. In addition, a number of studies have concluded that when instruction had been changed (even in a small way) to respond to how

students preferred to learn, increases in motivation as well as achievement levels are often the result [38 - 41].

As educators, we feel it important to be aware of the styles and types of our students. It would be ridiculous for us to think that we are teaching students that are just like ourselves. As we noted earlier, in a typical semester, our experience has been that in any given class, a wide range of student style and type preferences are present. The diversity of styles and types makes teaching and reaching ALL students a serious and critical challenge.

We further believe that one role we play as educators is to try and model for our students what it means to be successful in the real world once they graduate. It would not be wise for us to think that we automatically represent everything that will be necessary for student success after graduation. Awareness and acknowledgement of student difference is critical.

VI.   Summary and Conclusions

The need to identify individual learning style and/or personality type as a basis for providing responsive instruction has never been more important than it currently is. Instruction responsive to individual learning styles is especially critical as the pool of students who enroll in our classes continue to become more and more diverse.

As a final point, it must be emphasized that all of the studies on learning styles have been based on the study of large groups of people, thus, the definition of the types/styles have been based on the average of the group. As an instructor it is fine to use these results when considering the class as a whole, however, averages do not represent an individual. The bottom line is, every individual is unique. An awareness of this fact will provide the basis for effective instruction.

Through the specific teaching and learning strategies that have been described in this paper, we have attempted to demonstrate the importance of learning about learning styles and psychological types. As part of our ongoing research we are working to formally link the assessment of student learning styles to learning gains. To our knowledge, the use of the MBTI to assess personality type has not been directly linked to increased achievement. With that in mind, we are working to develop some correlational studies between style and type that could be linked to various achievement measures. Furthermore, through our continued studies, we are working to further ascertain the effectiveness of these approaches both in and out of the classroom in terms of their impact on science and engineering education for majors as well as non-majors.

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