Teaching to Students' Learning Styles: Approaches That Work

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Abstract - *In this paper, successful approaches to teaching undergraduate physics and engineering students using strategies developed from two independent learning style models will be described. The first learning style model to be described is the Dunn and Dunn Learning Style Model. The Dunn and Dunn Learning Style Model is employed with non-science majors enrolled in introductory physics at American University. The second model to be described is the Kolb Learning Style Model. The Kolb Learning Style Model is incorporated into the design of Counselor Tutorial (CT) courses for freshman engineering students at Purdue University. The basic elements of these two learning style models will be compared and contrasted. Teaching approaches designed to accommodate students' learning style preferences will be shared. These approaches include teaching and learning techniques that can be used in and out of the classroom. In particular, techniques utilizing these learning style models that have been effective in teaching students in large classes will be outlined. Ideas and approaches that have been successful with two distinctly different populations of students will be shared. These approaches can easily be adapted for use by educators in other branches of science, mathematics, engineering, and technology (SMET) education.*

Introduction

A growing body of research on adult learners suggests that increased learning gains can be achieved when instruction is designed with students' learning styles in mind [1 – 6]. In addition, several practitioners within the domains of physics and engineering education have noted the importance of teaching with learning styles in mind [7 – 14]. Furthermore, attention to learning styles and learner diversity has been shown to increase student motivation to learn.

This paper addresses the critical role that a learning style approach can play in terms of physics and engineering education. An overview of the learning style models used by the authors will be provided. Introductory physics students at American University are given a learning style assessment based on the Dunn and Dunn Learning Style Model. At Purdue University, a special set of tutorial courses for freshmen engineering students have been designed based on the Kolb Learning Style Model.

Two different student populations have been intentionally selected for discussion in this paper: non-science majors taking introductory physics at American University, and, at-risk freshman engineering students at Purdue University. These distinctly different populations of students allow us to share a very important message with other educators. The message is quite simple - a learning style approach CAN be successfully adapted for use with ANY population of students.

Description of Student Populations

American University

The introductory course for non-science majors at American University in Washington, D.C. is a one-semester, algebra-based course and is entitled *Physics for the Modern World*. Topics covered in the course typically include Kinematics, Newton's Laws, Conservation of Momentum and Energy, Rotational Motion, Fluid Mechanics, Waves, and Sound. Although traditional in its content, the course is not taught in a "traditional lecture format." Numerous teaching strategies have been developed which correspond to the accommodation of students' needs and diverse learning styles [15]. In addition, the course includes both strong conceptual and problem solving components.

Physics for the Modern World is a 3-credit course and consists of a lecture and a laboratory component. Students meet twice a week for class sessions that are 75 minutes long. On alternate weeks students meet for a two-hour laboratory. Approximately 120 students, with 60 students in each of two sections, enroll in the course each semester. The spring 1999 classes of *Physics for the Modern World* include students from 24 states and 25 countries. Nearly 40% of the class is made up of international students.

Many students who enroll in *Physics for the Modern World* are liberal arts majors. Students enroll in *Physics for the Modern World* to satisfy a portion of the Natural Science requirement for graduation at American University. Students may choose to satisfy this requirement with a general Physics, Chemistry, Biology, or Psychology course.

Purdue University

The population of interest at Purdue University involves students enrolled in an optional, Counselor Tutorial (CT) courses designed to provide supplemental instruction for academically disadvantaged students. The CT courses involve special one-on-one tutoring sessions that are held with an instructor from the Freshman Engineering Department, as well as once a week with undergraduate tutors. These courses are tailored for the individual who has the minimum understanding of the course material but who has not yet mastered the subject [16].

The particular CT course to be discussed later in this paper is called ENGR191M. ENGR191M provides supplemental instruction for students enrolled in MA151, *Algebra and Trigonometry.* MA151 is an algebra- and trigonometry-based course designed for students with inadequate preparation for calculus. Over 200 students typically enroll in ENGR191M each year.

Learning Style Described and Defined

What exactly is a learning style? Several definitions of learning style currently exist. Keefe [17] defined learning style as being characteristic of the cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. Learning style also represents both inherited characteristics and environmental influences.

Dunn [18] described learning style as "... the way each learner begins to concentrate, process, and retain new and difficult information" (p. 224) She noted that this interaction occurs differently for everyone. Dunn 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, maintain it, respond to his or her natural processing style, *and* cause long-term memory" (p. 224).

Dunn [19] noted that the uniqueness of individual learning styles could be thought of as a fingerprint. She said "Everyone has a learning style, but each person's is different - like our fingerprints which come from each person's five fingers and look similar in many ways" (p. 27). Interestingly, Sternburg [20] indicated that an individual's learning style can be compared to her/his ability and is therefore not etched in stone at birth. Dunn [21] further noted that a person's style can change over time as a result of maturation. Kolb [22] has suggested that "As a result of our hereditary equipment, most people develop learning styles that emphasize some learning abilities over others. Through socialization experiences in family, school, and work, we come to resolve the conflicts between being active and reflective and between being immediate and analytical in characteristic ways, thus lending to reliance on one of the four basic forms of knowing" (pp. 76 – 77). According to Kolb, these forms of knowing include: *divergence* (achieved by reliance on apprehension transformed by intention), *assimilation* (achieved by comprehension transformed by intention), *convergence* (achieved through extensive transformation of comprehension), *and accommodation* (achieved through extensive transformation of apprehension). These forms of knowing are described later in this paper.

Dunn contended that strong preferences can change only over a period of many years and that preferences tend to be overcome only by high levels of personal motivation. Dunn further asserted that teachers cannot identify students' styles without the use of appropriate instruments. Assessing a person's unique style is vital to the teaching/learning process. Dunn also asserted that a match between a student's style and a teacher's style will lead to improved student attitudes and higher academic achievement. The Dunn and Dunn Learning Style Model is used with students at American University while the Kolb Learning Style Model is used with students at Purdue University. These learning style models are described in the sections that follow.

Description of the Dunn and Dunn Learning Style Model

Many different learning style assessment models and instruments are available. De Bello [23] indicated 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. 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 [24].

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 De Bello noted, 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 learning style assessment instrument chosen for this study is the Productivity Environmental Preference Survey (PEPS) by Dunn, Dunn, and Price. This instrument was chosen because of its comprehensive nature, and, because of the relative ease of assessing students and interpreting the results. The PEPS was developed from the Dunn and Dunn Learning Style Model and is described in the following section. The Dunn and Dunn Learning Style Model is based on five different categories: (1) Environmental, (2) Emotional, (3) Sociological, (4) Physiological, and (5) Psychological. These categories provide the basis for the elements displayed in the feedback profile obtained after student responses to the PEPS have been scored.

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, to date, 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 Productivity Environmental Preference Survey (PEPS)

The PEPS consists of 100 questions on a Likert scale. This instrument uses a standardized scoring system that includes scores that range from 20 to 80. The scale is further broken down into three categories. These categories are referred to here as Low, Middle and High. The Low category represents standard scores in the 20 - 40 range; the Middle category scores in the 41 - 59 range; and the High category scores in the 60 - 80 range. Individuals who have scores lower than or equal to 40 or higher than or equal to 60 for a particular element find that variable important when they are working. Individuals who have scores in the Middle category find that their preferences may depend on many factors such as motivation and interest in the particular topic area being studied.

Looking at one specific example, within the category of environmental stimuli are the elements of sound, light, temperature and design (formal versus informal). The elements within this category are self-explanatory. This category is one that is difficult to accommodate in the classroom. However, learners can easily satisfy their preferences when working outside of class. For example, a score ≥ 60 for the element of sound would mean that an individual has a preference for sound when learning new and difficult information. An individual could accommodate their preference for sound by listening to soft music. A score ≤ 40 on the sound element would imply that an individual does not show a preference for sound and thus should work in a quiet environment (using earplugs if necessary). A score in the middle category means an individual might prefer sound at one time, and not at another.

Once the PEPS is administered, students should receive an individual feedback profile as quickly as possible. Students must immediately be made aware that no high or low exists on this scale in terms of superiority of scores. Furthermore, no scores are bad scores - all are simply unique. No scientific evidence shows that one type of learning style is academically superior over others.

Numerous research studies [25] have documented the reliability and validity of the PEPS. Dunn and Dunn [26] posited that research on their model is more extensive and more thorough than research on many educational topics. As of 1998 research utilizing their 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. [27] 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 from 1989 to 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 of students whose learning styles have not been accommodated. Further, when instruction is compatible with students' learning style preferences, the overall learning process is enhanced.

Description of the Kolb Learning Style Model

David Kolb, a cognitive theorist, developed the *Learning Style Inventory* (LSI) in 1976 [28]. The LSI was a 9-item self-report questionnaire in which four words describing one's style were rank-ordered. One word in each item was used to correspond to one of four learning modes [29]. Within the Kolb Learning Style Model four learning modes are identified: (1) *Concrete Experience* (CE), (2) *Reflective*

Observation (RO), (3) *Abstract Conceptualization* (AC), and (4) *Active Experimentation* (AE).

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. 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 *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. Finally, 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.

In his work Kolb identified four statistically prevalent learning styles [30]. These styles are referred to as the *Diverger*, the *Assimilator*, the *Converger*, and the *Accommodator*. Felder describes these styles as Type I, Type II, Type III, and Type IV respectively [31]. Figure 1 shows that these styles (or types) can be graphed on a coordinated grid illustrating the bipolar dimensions of *doing* (active experimentation) versus *watching* (reflective observation) on the x-coordinate, and *feeling* (concrete experience) versus *thinking* (abstract conceptualization) on the y-coordinate [32].

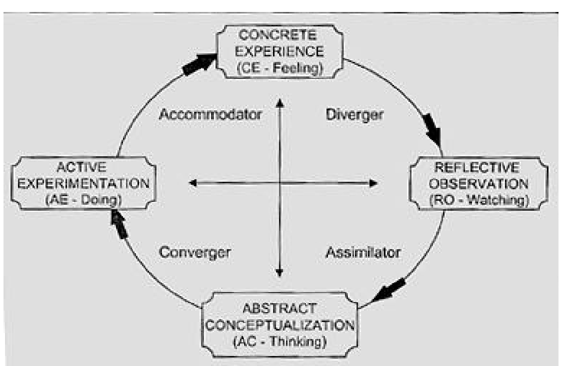

Figure 1. Kolb's Learning Style Model

The *Diverger's* (Type I) dominant learning abilities are Concrete Experience and Reflective Observation. These learners are able to put their creative imagination to good use. 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.

The *Assimilator's* (Type II) dominant learning abilities are Abstract Conceptualization and Reflective Observation. Assimilators are less interested in people and are more interested in abstract concepts. Assimilators are very good at synthesizing disparate observations into an integrated explanation. They work well when information is detailed, logical, and orderly.

The *Converger's* (Type III) dominant learning abilities are Abstract Conceptualization and Active Experimentation. Convergers seem to do best when there is a single correct answer to a problem or question. These individuals tend to be less emotional and do not like to waste time. Convergers would prefer to work with things and not people.

The *Accommodator's* (Type IV) dominant learning strengths are Concrete Experience and Active Experimentation. The accommodator tends to be a risk-taker. Accommodators are intuitive and tend to do well in situations that call for adaptation to specific immediate circumstances. These individuals tend to work easily with other people, yet can sometimes be viewed as being impatient.

Teaching and Learning Approaches: Strategies Utilized at American and Purdue Universities

American University

All students enrolled in *Physics for the Modern World* at American University are given the PEPS at the beginning of the semester. Students receive an individualized feedback profile approximately two weeks after that. The profile is similar to a prescription in that it identifies categories (based on the Dunn and Dunn Model) in which students have strong preferences and gives them information as to how to best utilize these strengths. Students are also extended an invitation to visit with the instructor individually regarding their learning style profiles.

Teaching approaches utilized in the physics course have been designed, in part, using the Dunn and Dunn Learning Style Model. Two unique teaching approaches will now be briefly described. One approach involves a unique writing activity called a *folder activity*. A second approach involves the use of a peer-led and instructor-moderated on-line discussion group.

Approach (1): The *Folder Activity*

The first teaching approach to be described is the *folder activity*. The folder activity was developed to help students elicit and confront their misconceptions in physics in a non-threatening way [33]. The folder activity allows for direct feedback between the individual students and the instructor.

In addition, the folder activity allows students to be creative and use their unique learning style preferences.

As part of their homework assignments, students are required to keep a two-pocket folder. Students receive 5 - 10 writing assignments each semester. Upon collection of the folders, a block of time is set aside (approximately 6 - 8 hours) to read them and provide each student with written feedback. This written feedback is absolutely essential. When students take time to reflect on their writing and on the instructor's comments the folder becomes a highly effective tool in helping them uncover and then wrestle with their misconceptions while the learning is taking place. Typical folder activities range in length from 1 - 4 pages.

The specific emphasis of the writing activities depends on the goals and objectives for a particular topic or content area. For example, for some activities students are asked to explain a problem or a concept that was highlighted or discussed during a class session. Thus, students essentially have the "answer" to the problem in their hands when they write up this folder assignment. The rationale for this type of activity is that learning can be enhanced when students take on the role of teacher through their detailed responses and explanations.

An additional example of a typical folder activity involves the creation of sample exam questions. In addition to writing a question, students must explain their choice of responses (i.e. for multiple choice questions) including the reasoning behind both the correct response as well as the incorrect options.

Students are encouraged to share their understanding of the particular topic or concept in their own words. Thus, students are not pressured to bog their writing down with scientific jargon. This provides a much clearer window into the students' thoughts and to their level of understanding.

An important aspect of the folder activities is that students are permitted to be as creative as they would like to be. They are encouraged to write their responses in a fashion that allows them to make use of their individual learning styles. For example, some students like to enhance their writing through the use of manipulatives and artistic drawings. Other students might choose to write their responses in the form of a story or short play. The students know that they have complete control of this activity and are free to put their learning styles to good use!

Approach (2): The On-line Discussion Group

The second teaching approach used with introductory physics students involves the use of an on-line discussion group. The on-line discussion group is a useful way of allowing for peer-, rather than instructor-given feedback. The on-line discussion group has also proven to help students elicit and confront their misconceptions [34].

The on-line discussion group used with the introductory physics students is peer-led and instructor-moderated. The most common use of the discussion group by the students is for discussion of homework questions. A student may post a specific question to the group, describe their confusion, and ask for assistance. Other members of the class are then free to jump in and offer the student help and advice. If the students fall off course with their discussion, the instructor will offer some guidance and attempt to steer the discussion back on track. Other uses of the discussion group include posting of announcements and general discussion questions by the instructor.

The use of an on-line discussion group offers a relatively new avenue through which the learner can take an active role in the learning process. Furthermore, an on-line discussion group is one form of computer-assisted communication that promotes interactive engagement of the learner with the content being studied. In addition, an on-line discussion group may offer some students a more "comfortable" environment in which to interact than the traditional large lecture class. In addition, an on-line discussion group may appeal to students with diverse learning styles.

Purdue University

The standard, first-semester mathematics course for engineering students at Purdue University is calculus. However, approximately 20% of the entering students are not calculus-ready and must start in MA151, *Algebra and Trigonometry*. To assist these students, the Schools of Engineering offer a supplemental instruction Counselor Tutorial (CT) course, ENGR191M, that is designed to help the academically disadvantaged become calculus-ready.

Studies [35 – 37] have shown that if students are successful in MA151, then retention rates for these students do not differ significantly from that of students who are initially better prepared. Students in the ENGR191M course are not treated as remedial students, however. Furthermore, the ENGR191M course is organized in such a way so as to acknowledge learner diversity through the recognition of individual learning styles. To accomplish this, the ENGR191M course was designed around the Kolb Learning Style Model. Specific examples of applications of this model are given in the discussion that follows.

The ENGR191M Course at Purdue: Applications of the Kolb Model

Divergers (Type I) are students who perceive information through concrete experience, rely on feeling, need to express feelings when learning, seek personal meaning as they learn, and desire personal interaction with the instructors as well as other students. To be effective with Type I students, the instructor should function as a motivator. Thus, the instructor should develop ways to motivate these students and show them how the course material fits into the big picture.

Type I students benefit from individual counseling. To accomplish this, the ENGR191M course has a one-on-one counseling component where each student meets once a week with an instructor to discuss both the successes and failures for the past week. During this time, the student is given time to reflect on how this as well as other course work fits into the big picture as it relates to their particular area of engineering.

Assimilators (Type II) perceive information through abstract conceptualization and process material through reflective observation. 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. Type II learners do well in traditional school settings. To be most effective with Type II learners, the instructor should function as an expert. Thus, the instructor's role is one of an authority figure and information giver.

Assimilators like to listen to lectures and prefer that the instructor present course material in an organized and accurate manner. Thus, for these students, the ENGR191M course has a lecture component where an engineering faculty member presents a weekly lecture that summarizes the course material each week.

Convergers (Type III) perceive information through abstract conceptualization and process it actively. These individuals like to test information, to try things, to take things apart, to see how things work, and to learn by doing. Type III learners 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. To be effective, the instructor should function as a coach, providing guided practice and feedback. Thus, an instructor needs to become less actively involved and allow the students to take a more active role in the learning process.

One of the components of the ENGR191M course involves the requirement that any test taken or assignment prepared by a student in the MA151 course in which a B grade or below is received must be repeated with the assistance of a tutor. This component of the ENGR191M course design allows the individual who is experiencing success to be rewarded with a simple check-in, while simultaneously giving other students valuable one-on-one tutoring without causing embarrassment that might otherwise occur in a traditional classroom setting. Furthermore, this component of the ENGR191M course was actually designed to assist Type I students but it also serves to act as a motivator for Type III students who benefit from personal interaction with the instructor and tutors.

Accommodators (Type IV) perceive information through concrete experience and process it through active experimentation. These individuals enjoy interacting with others through group activities and discussion. Type IV learners are problem solvers and risk takers, typically learning from their mistakes. These individuals can be referred to as accommodators because they take what they have learned and adapt it for their own uses. To be most effective, the instructor should stay out of the way, while simultaneously maximizing the opportunities for students to discover things for themselves. Thus, the instructor's role tends to be that of an evaluator and remediator.

Type IV learners thrive when the instructor encourages self-discovery. This approach provides these students a needed opportunity to teach themselves while still allowing for some interaction and minimal supervision from the instructor. For this group of learners, the ENGR191M course has a component which permits students to meet in small groups with an undergraduate tutor once a week to demonstrate his/her progress in the MA151 class (homework, quizzes, tests) and to work on a special CT problems with the tutors.

In summary, the ENGR191M course has several components that have been designed in accord with the Kolb Learning Style Model. This unique course design offers students with particular learning style characteristics to benefit from a wide range of learning opportunities.

Conclusions

Acknowledgement of students' individual learning styles can play a critical role in the learning process. Further, the use of formal learning style assessments can provide useful information that benefits the student as well as the instructor. We believe that the learning style assessment tool used is not as critical as the actual assessment of learning styles. Through the specific teaching and learning strategies that have been described in this paper, we have demonstrated the value and importance of adopting a learning style approach in the classroom. In addition, we have provided evidence of the value of a learning style approach with two distinctly different populations of students. We believe that the attention given both populations of students in terms of individual learner diversity and learning styles is critical to the success of these teaching and learning strategies.

As part of our ongoing research we are working to formally link the assessment of student learning styles to learning gains. Through our continued studies we plan to further ascertain the effectiveness of a learning style approach in and out of the classroom in terms of its impact on student learning within the domains of physics and engineering education.

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