Teaching With *STYLE*: Strategies That Work

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Abstract

This paper will review two particular learning style models and their application to physics and engineering education. The first 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 utilized with engineering students at Purdue University. The basic elements of these two learning style models will be compared and contrasted. Specific examples regarding teaching and learning strategies utilized at these institutions which have been designed based on these learning styles models will be briefly described. Central to each strategy is the fact that when students' individual learning style 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.

I. 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 - 15]. In addition, several practitioners within the domains of physics and engineering education have noted the importance of teaching with learning styles in mind [16 - 23]. 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. Two different student populations have been selected for discussion in this paper: non-science majors taking introductory physics at American University and at-risk freshman engineering students at Purdue University.

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. Teaching strategies in the introductory physics class have been designed to include a learning style approach. At Purdue University, a special set of tutorial courses for freshmen engineering students have been designed based on the Kolb Learning Style Model.

A brief comparison of these two learning style models will be shared. We will conclude this paper with a description teaching and learning strategies that have been successful in working with these two 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.

II. 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 [24]. 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.

Many students who enroll in *Physics for the Modern World* are liberal arts majors. A typical class consists of a mixture of students from the College of Arts and Sciences, the School of Public Affairs, the School of International Service, and the Kogod College of Business Administration. 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.

Due to the wide range of majors in the course, one could assume that the diversity of students enrolled in *Physics for the Modern World* closely parallels the diversity of students enrolled at American University. The 1995 - 96 American University catalog describes its student population as being "... cosmopolitan and multicultural ..." [25]. 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.

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 [26].

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.

III. Learning Style Described and Defined

What exactly is a learning style? Several definitions of learning style currently exist. Keefe [27] 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. Keefe and Ferrell [28] further summarized learning style as a complexus of related characteristics in which the whole is greater than its parts. Learning style is a gestalt combining internal and external operations derived from the individual's neurobiology, personality, and development and reflected in learner behavior. Learning style also represents both inherited characteristics and environmental influences.

Dunn [29] 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). To reveal these factors, the learning style model must be comprehensive.

Dunn [30] noted that the uniqueness of individual learning styles can 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 [31] indicated that an individual's learning style can be compared to her/his ability and is therefore not etched in stone at birth. Dunn [32] noted that a person's style can change over time as a result of maturation. She reported [33]:

> In 1979, Armin Thies of Yale University was the first to report that at least three-fifths of the Dunn and Dunn Learning Style Model elements are genetically imposed. For example, individual responses to learning with: Sound versus Quiet, Soft versus Bright Lighting, Warm versus Cool Temperatures, and Formal versus Casual Seating are biological. Also genetic in origin are Perceptual Strengths (auditory, visual, tactile and kinesthetic), learning with or without Intake (snacks), Time-of-Day energy high and lows, and Passivity versus Mobility needs. Conversely, Thies determined that the sociological preferences for Learning Alone, with one or more friends, with an authoritative versus a collegial teacher, and for being comfortable with patterns and routines as opposed to preferring a variety of instructional resources, develop over time through each person's experiences and therefore, are developmental. Thies perceived that Motivation, Responsibility (which correlates with conformity/non-conformity), and external versus internal Structure are also developmental. (p. 82)

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.

IV. Description of the Dunn and Dunn Learning Style Model

Many different learning style assessment models and instruments are available. De Bello [34] 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. Some learning style instruments as described by De Bello include those of several theorists including Dunn & Dunn, Hill, Letteri, Ramirez, Reinert, Schmeck, Hunt, Kolb, Gregorc, and McCarthy. 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 [35].

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 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)

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 Productivity Environmental Preference Survey (PEPS)

In summarizing the categories of the PEPS, one finds that the emotional category has elements of motivation, persistence, responsibility and structure. The sociological category has elements that assess whether an individual prefers to work alone or in a group, whether feedback from an authority figure is preferred, and whether variety enhances learning. The physical category provides information regarding an individual's perceptual modality preferences (i.e. auditory, visual, tactile and kinesthetic). The physical category also includes items like preference for intake while learning and preference for best time of day. Finally, the psychological category allows one to make interpretations regarding cognitive processing (i.e. global versus analytic processing). Research studies have found that the elements of sound, light, temperature, design, perception, intake, chronobiological highs and lows, mobility needs, and persistence appear to be biological in nature. Sociological elements as well as motivation, responsibility (i.e. conformity), and the need for structure are thought to be developmental in nature.

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. For example, individual preferences falling into the middle range may be dictated by other items such as motivation and interest in the particular topic area being studied. This information is useful both for teachers and students. Students can be instructed to capitalize on their learning strengths and build upon their weaknesses.

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. In this case an individual's preference would depend on other factors.

Once the PEPS has been administered, students should receive this feedback profile as quickly as possible. The standardized scores (ranging from 20 to 80) that form the basis for an individual's learning style profile may be easily misinterpreted. Students immersed in an academic environment may tend to interpret a higher score as being better than a lower score. 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 ever bad scores - all are simply unique. The message to the student must be clear: learning styles are unique to the individual and are not to be labeled as being good or bad. No scientific evidence shows that one type of learning style is academically superior over others.

Numerous research studies [36] have documented the reliability and validity of the PEPS. Dunn and Dunn [37] 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. [38] 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. There 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.

Dunn, et al. further suggested the need to identify individual learning styles 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.

V. Description of the Kolb Learning Style Model

David Kolb, a cognitive theorist, developed the *Learning Style Inventory* (LSI) in 1976 [39]. 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 [40]. 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. This mode also involves dealing with experiences in a personal way. 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. These people tend to focus on logic, ideas, concepts, and theory-building. Such people tend to have a scientific approach to problem solving as opposed to a more artistic approach. Finally, the *Active Experimentation* mode describes people 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 [41]. 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 [42]. 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 [43].

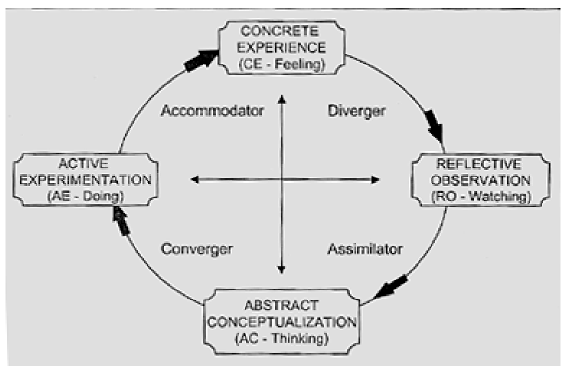

Figure 1. Kolb's Learning Style Model

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. They excel at creating theoretical models, yet are less concerned with the practical use of the theories. 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. These learners excel when given the opportunity to apply ideas in a practical way. 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. They excel when given the opportunity to do things such as carry out experiments and become involved in new experiences. 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.

VI. Teaching and Learning Strategies: Specific Examples

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 a written learning style 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.

A variety of teaching strategies are utilized to accommodate the diversity of learners enrolled in this physics class. The teaching strategies are designed using the Dunn and Dunn Learning Style Model. Two of these strategies will be briefly described here. One strategy involves a unique writing activity called a *folder activity*. The second strategy involves the use of a peer-led and instructor-moderated on-line discussion group.

The first teaching strategy 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 [44]. In addition, the folder activity allows students to be creative and use their unique learning style preferences. Furthermore, the folder activity allows for direct feedback between the individual students and the instructor.

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 my comments the folder becomes a highly effective tool in helping them uncover and then wrestle with their misconceptions while the learning is taking place.

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 the kind of activities students are asked to respond to in their folders 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.

Once students complete their folder assignments they are asked to read them over to see if they have addressed everything asked for in the assignment. Students are sometimes required to have someone else, who is preferably unfamiliar with physics, read their responses and comment on them BEFORE they are submitted. Typical folder activities range in length from 1 - 4 pages.

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!

The second teaching strategy to be described 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 [45].

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 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 course ENGR191M that is designed to help the academically disadvantaged become calculus ready. Although the students in the ENGR191M course are in need of help, the help course has been designed in such a way so as not to treat them as remedial students. Furthermore, this course has been designed to provide students a safety net and is taught in a fashion that does not demean or belittle their abilities. To accomplish this, the ENGR191M course is organized in such as way so as to acknowledge learner diversity through the recognition of individual learning styles.

Studies [46 - 48] 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 better prepared. However, for the MA151 students to be successful they must perform at an A-level. Thus, the ENGR191M course was created to help foster students be successful and to encourage them to strive for excellence. The ENGR191M course was developed, in part, using the Kolb Learning Style Model. Specific examples of applications of this model are given in the discussion that follows.

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. Divergers need to be given a reason as to why material presented is important to them personally and/or to others with whom they can identify or feel empathy. A characteristic question of this learning type is "Why?" Type I learners respond well to explanations of how course material relates to their experience, their interests, and their future careers as engineers. These individuals learn well through discussion and they excel at brainstorming. 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. Divergers want to interact personally with the instructor and to be recognized as individuals. An instructor should monitor and witness the students' personal growth. Type I students also benefit through the use of such things as small group workshop problems because they allow students an opportunity to brainstorm and interact with their peers. However, these students also 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 also given the time to reflect on how this as well as other course work all 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. A characteristic question of this learning type is "What?" Type II learners respond to information presented in an organized, logical fashion and benefit if they have time for reflection. 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. In addition, Type II learners typically do not like group work. These learners will perform group work when assigned, however, because their learning style includes a need to follow established procedures and protocols.

Convergers (Type III) perceive information through abstract conceptualization and process it actively. A characteristic question of this learning type is "How?" Type III learners respond well when they are given opportunities to work actively on clearly 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. Type III learners want to see the practicality and usefulness of the information they are learning. These learners do not favor sitting for long periods of time in lecture or reading a great deal of material. In addition, they like to get things done without wasting any time. 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. These learners like to have structured models to follow and do not prefer a lecture environment. These individuals tend to see group work and class discussion as a waste of time because they feel they can get their work done more quickly and efficiently by themselves. To be effective, the instructor should function as a coach, providing guided practice and feedback. Type III learners tend to prefer that an instructor help them when needed as they experience a lesson on their own. 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 strategy is utilized until the student receives a grade of B or better on the specific task they had trouble with in the MA151 course. 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. This particular component of the ENGR191M course was designed to assist Type I students but also acts as a motivator for Type III students who also benefit from personal interaction with the instructor and tutors.

Accommodators (Type IV) perceive information through concrete experience and process it through active experimentation. A characteristic question of this learning type is "What if?" Type IV learners like applying course material in new situations to solve real problems. These learners are enthusiastic and prefer learning through self-discovery. Type IV learners tend to follow their own timetable when learning and resent being given an abundance of structured procedures and rules. These individuals enjoy interacting with others through group activities and discussion. In addition, they like to take information and create something new with it and to discover things on their own. 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. The end result is the Type IV learner excels when they are given an opportunity to use their individual creativity to change things and make them better. 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. Type IV learners prefer the instructor to stay in the background, to serve as a resource, and to evaluate what they have done. 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. The ENGR191M tutors also make use of specially designed workshop problems that challenge students to use the mathematics skills they are learning in MA151 to solve new and more difficult problems.

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.

VII. 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.

As part of our ongoing research we are working to formally link the assessment of student learning styles to learning gains. Certainly, information regarding whether students with particular learning style strengths learn more and perform better than those students without the same strengths is of interest. Thus, 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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