

Learning Styles in the Physics Classroom: A Research-informed Approach

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ABSTRACT

This paper explores relevant research documenting that a learning-style approach in the classroom leads to enhanced learning gains. Particular emphasis will be placed on the Dunn and Dunn Learning Style Model. The basic tenets of this learning-style model are highlighted. The Dunn and Dunn model forms the basis of the Productivity Environmental Preference Survey (PEPS) which is a valid and reliable learning-style identification instrument. The PEPS is currently being used as a research tool within the introductory physics course for non-majors at American University. Two teaching approaches that have been developed based on a learning-style approach will be shared. These approaches include the use of writing as well as interactive, live online chats using Blackboard technologies. Ideas for effective adaptation of these approaches by educators in other branches of science, as well as mathematics, engineering, and technology (SMET) education are discussed.

I. INTRODUCTION

The brisk changes that continue to occur in modern society, and in academia in particular, suggest that learning must be a continuous process. 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 domain of physics, as well as 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 interest and motivation to learn.

The particular population of students that encompasses the focus of this paper is non-science majors taking introductory physics at American University. Most students take this introductory course to satisfy the university's General Education requirements for graduation. Because the backgrounds and ability levels of this group of students is quite broad-based and diverse, it is anticipated that the teaching and learning strategies to be described in this paper can be adapted for use with other populations of students as well. The underlying message is quite simple - a learning-style approach CAN be successfully applied with ANY population of students.

This paper addresses the critical role that a learning-style approach can play in terms of teaching introductory physics. A detailed overview of the learning-style model used by the author will be provided. In addition, two specific teaching and learning strategies developed, in part, from current research on learning styles will be highlighted. These strategies involve extensive use of writing as a teaching and learning tool as well as the use of live, online chats

using Blackboard technologies. Student perceptions regarding these strategies will also be shared.

II. DESCRIPTION OF STUDENT POPULATION

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 (PMW)*. Topics covered in this 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. Many traditional teaching methodologies have clearly been shown to put students in the role of passive, rather than active, learning [15]. Numerous teaching strategies have been developed that serve to better accommodate students' needs and diverse learning styles [16]. In addition, the course includes strong conceptual and problem solving components.

PMW is a 3-credit course and consists of a lecture and a laboratory component. Students met twice a week for class sessions that are 75 minutes long. On alternate weeks, students met for a two-hour laboratory. Approximately 120 students, with 60 students in each of two sections, were enrolled in the course. Approximately 20% of the class was made up of international students.

Attention to learning style and learner diversity began on the first day of class and continued throughout the semester. Students were given a learning-style assessment on the first day. The assessment is completed and returned for analysis during the next class period. The analysis process takes approximately one week, at which time students were given an individualized learning style profile for their personal use. Students were also asked to write about their individual learning-style preferences during their first writing assignment. Before a more detailed discussion of the specific teaching and learning strategies that utilize a learning style approach can be outlined, a description of learning style and the learning-style model that is used in PMW will be presented.

III. 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 is a gestalt of combining internal and external operations derived from the individual's neurobiology, personality, and development reflected in learner behavior. 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] has suggested 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." (pp. 76 – 77).

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. She further asserted that teachers cannot identify students' styles without the use of appropriate instruments. Assessing an individual's unique style is vital to the teaching/learning process. A significant number of research studies have shown that students instructed in a classroom environment where individual learning differences are acknowledged and accepted are more receptive and eager to learn new and difficult information [23 – 28]. Dunn also suggested that a match between a student's style and a teacher's style will lead to improved student attitudes and higher academic achievement. A description of the Dunn and Dunn learning-style model employed with students enrolled in PMW is given in the next section.

IV. DESCRIPTION OF THE DUNN AND DUNN LEARNING STYLE MODEL

Many different learning-style assessment models and instruments are currently available. De Bello [29] 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. In particular, one multidimensional model is that developed by Dunn and Dunn. This section will focus on the learning-style model developed by Dunn and Dunn [30] as shown in Figure 1 and the associated learning-style assessment instrument developed by Price, Dunn, and Dunn [31] called the Productivity Environmental Preference Survey (PEPS).

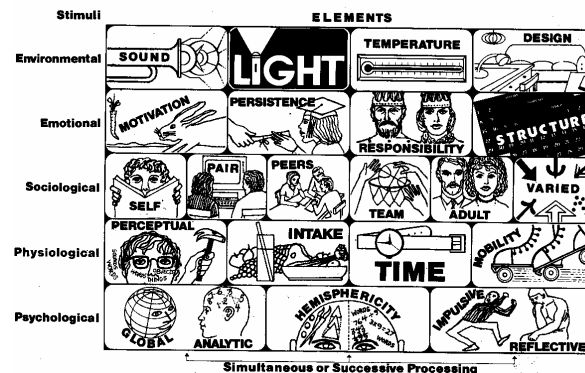


FIGURE 1. THE DUNN AND DUNN LEARNING STYLE MODEL

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 learning style assessment instrument chosen for this study was 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. As Figure 1 shows, 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 physics as well as in other branches of science and engineering education has been quite limited. As a result, the use of this model in physics, as well as in other branches of science and engineering education becomes even more interesting to study.

V. 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 a range from 20 to 80. The scale is further divided into three

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categories. These categories are referred to here as Low, Middle, and High and are represented in Figure 2. The Low category represents standard scores in the 20 - 39 range; the Middle category scores in the 40 - 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.

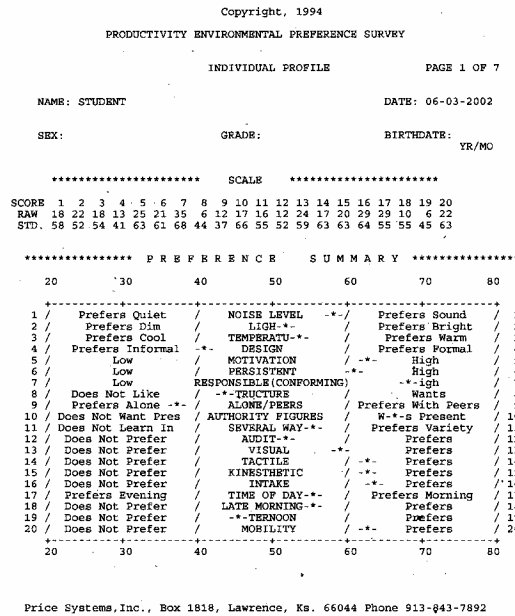


FIGURE 2. RESULTS OF THE PEPS (reprinted with permission)

Looking at one specific example, within the category of the environmental stimulus are the elements of sound, light, temperature and design (formal versus informal seating). The elements within this category are self-explanatory. This category is one that might appear to be challenging to accommodate in the classroom. However, some examples of how learners could accommodate their preferences within this category include bringing a cushion to sit on, sitting away from the windows if dim light is preferred, and bringing a sweater or light jacket and then discarding it as need be. In addition, learners can easily satisfy their preferences when working outside of class. In terms of interpretation of scores, a score ≥ 60 for the element of sound would mean that an individual has a preference for sound while learning new and difficult information. Individuals could accommodate this preference for sound by listening to soft music on a headset. 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 such as interest in what is being learned or personal motivation to achieve.

Once the PEPS was administered, students received an individual feedback profile as quickly as possible. Students immediately were made aware that no high or low exists on this scale in

terms of superiority of scores. Furthermore, no scores are either bad or good - all are simply unique. No scientific evidence shows that one type of learning style is academically superior over others.

Numerous research studies [32] have documented the reliability and validity of the PEPS. Dunn and Dunn [33] posited that research on their model is more extensive and more thorough than research on many educational topics. As of 2003, research utilizing their model had been conducted at more than 120 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. [34] performed a meta-analysis of the Dunn and Dunn model of learning style preferences. They reviewed 42 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 could 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.

The following section highlights two instructional approaches developed for use with introductory physics students. The underpinnings of each approach are grounded, in part, in the results of current research on learning styles.

VI. TEACHING AND LEARNING APPROACHES: STRATEGIES TO ENHANCE STUDENT MOTIVATION AND INTEREST

All students enrolled in *Physics for the Modern World* at American University were given the PEPS at the beginning of the semester. Students received a computerized individual feedback profile approximately one week after that. This 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 were also extended an invitation to visit with the instructor individually regarding their learning-style profiles. The instructor also maintained a copy of each student's profile and made use of that when working with individuals during office hours.

Teaching approaches utilized in the introductory physics course were 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 writing activity called a *folder activity*. A second approach involves the use of a live, interactive, online chats that make use of Blackboard technologies. These approaches are described in the following sub-sections.

APPROACH (1): WRITING ACTIVITIES

The first teaching approach to be described involves the use of writing and is called a *folder activity*. Writing has long been established as an effective means of expressing one's ideas, thoughts, and understandings about nature and the world. The folder activity was developed by

the author more than 10 years ago to help students elicit and confront their misconceptions in physics in a non-threatening way [35]. This activity is particularly important as science classes are often viewed by many students as threatening and intimidating places to be. The folder activity also allowed students to be creative and use their unique learning-style preferences when they prepare their written responses. Writing can also be a very effective vehicle for allowing students to develop and enhance their critical thinking and problem-solving skills.

As part of their homework assignments, students were required to keep a two-pocket folder. Students received approximately five writing assignments during the semester. Upon collection of the folders, a block of time was set aside (approximately six to eight hours) to read them and provide each student with written feedback. This direct 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 actually taking place. Typical folder activities were approximately one to four pages in length. To eliminate some of the burden on the instructor of reading 120 papers at a time, assignments were sometime alternated between sections. For example, a folder assignment was sometimes given to the first section *prior* to the introduction of a new topic, and the same assignment given to the second section *after* discussion of the topic has take place. This strategy allowed the instructor to gauge where students were in terms of their understanding of a topic both before and after it had been covered in class. If the students' writing showed that they had not made the desired progress on a particular topic, additional class time was devoted to that topic.

The specific emphasis of the writing activities depended on the goals and objectives for a particular topic or content area. For example, for some activities, students were asked to explain a problem or a concept that was highlighted or discussed during a class session. Thus, students essentially had the "answer" to the problem in their hands when they wrote the 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 involved 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 were always encouraged to share their understanding of the particular topic or concept in their own words. Thus, students were not pressured to bog their writing down with scientific jargon. This provided a much clearer window into the students' thoughts and level of understanding and often offered deeper insight than could be ascertained from traditional paper and pencil assessments. In addition, as the semester progressed, students began to naturally make more and better use of scientific terminology in their writing.

An important aspect of the folder activities is that students were permitted to be as creative as they would like to be. They were encouraged to write their responses in a fashion that allowed them to make use of their individual learning styles. For example, some students liked to enhance their writing through the use of manipulatives and artistic drawings. Other students

chose to write their responses in the form of a story, a poem, or a short play. The students knew that they had complete control of this activity and that they were free to put their learning styles to good use!

The assessment of the folder activities was somewhat unique in that students were not penalized for incorrect use of physics. Not penalizing students helped make the folder activities non-threatening. The written feedback provided by the instructor indicated to the students that their writing was taken very seriously, and that it should be used as a vehicle to promote understanding. In addition, numerical scores were not put on students' papers until the end of the semester. The intent here was to get the students to pay attention to the written feedback from the instructor and not the grade they received. For example, if a student received a score of 17/20 on an assignment they might be tempted to say to themselves "Well, 17/20 is a pretty good score, I'm happy with that" and then never look at the assignment again. Then later, these three points they missed could come back to haunt them on an exam, when the three points have now magnified into many more. The bottom line is that students were repeatedly encouraged to take the time to understand the flaws in their thinking, and if they simply filed a graded assignment into their notebooks, then no real learning has taken place.

Students were provided a grading rubric in the course syllabus and they understood that, as long as they completed the assignment according to the prescribed directions, they would receive full credit. The purpose of this grading scheme was to encourage students to think deeply about the comments they have received and then do whatever they needed to do to correct any problems with their thinking and understanding of a particular topic or concept. Students were very comfortable with this grading scheme, and genuinely enjoyed receiving the written feedback provided on their folder assignments.

APPROACH (2): INTERACTIVE ONLINE CHATS USING BLACKBOARD TECHNOLOGIES

The second teaching approach used with introductory physics students involves the use of live, interactive online chats using Blackboard technologies. This approach was piloted during the fall 2002 semester. The use of online chats allowed students to use other aspects of their learning style preferences in addition to those used in the writing activities. In particular, students satisfied their need to work in a group environment. Since students chose where they wanted to be when they logged into the chats, they simultaneously satisfied their individual preferences in the environmental category. Furthermore, since the instructor participated in the discussions, students satisfied their preference to work with an authority figure present.

The *Blackboard Learning System*TM [36] is a technology platform aimed at achieving several objectives including:

- 1) Measuring and improving student performance.
- 2) Increasing instructor productivity.
- 3) Enabling "Web-enhanced" classroom-based teaching and learning.
- 4) Delivering distance learning.
- 5) Supporting lifelong continuing education.

- 6) Blending the benefits of face-to-face and online learning through the use of hybrid courses.
- 7) Leveraging technology to enhance institutional competitiveness, applicant selectivity and retention.
- 8) Providing a platform framework that integrates course and learning management capabilities with an organization's student information, security, and authentication protocols.
- 9) Providing a framework for managing an institution's digital assets and content. (p. 3)

The *Blackboard Learning System*[™] also featured an online environment that has been designed to supplement either traditional learning or distance learning. Through an intuitive interface, instructors can manage online environments for teaching and learning by using the following utilities:

- 1) Content Management and Content Sharing.
- 2) Assessment Management.
- 3) Gradebook.
- 4) Collaboration and Communication.
- 5) Assignment and Portfolio Management. (p. 4)

The particular feature to be explored here involves the collaboration and communication utility of Blackboard. During the fall 2002 semester all students in PMW were enrolled in a course-specific Blackboard site. Students had immediate access to course documents such as syllabi and assignments. The instructor communicated with all students by email through the Blackboard site to send reminders, announcements, etc. In addition, the Blackboard site provided a forum for interactive online chats. The chats were similar in nature to *AOL Instant Messenger*[™] (AIM) [37] that is so commonly used by students to chat with their friends on the web. With AIM the chats with friends appear on separate screens. Thus, if a student is chatting with several friends simultaneously, the desktop contains a screen for each person with whom they are chatting. The unique feature of Blackboard is that the instructor and students can chat on a single screen. This feature allowed for a continuous discussion to take place between everyone logged into the chat.

The online chats provided a useful way of allowing for peer-, as well as instructor-given feedback. In addition, the online chats allowed students to use a different form of writing to communicate with their peers. The online chats have also proven to help students elicit and confront their misconceptions [38]. The most common use of the chats was for the discussion of homework questions. During the semester, chats were routinely scheduled for a day or two prior to the date that a homework assignment would be collected. The chats were typically set up on different days of the week and at different times each week so as to allow more students an opportunity to participate. The chats were not required, but rather were advertised as an additional way for students to get assistance on their homework when they needed it. One feature of Blackboard allowed the instructor to prohibit anonymous postings. Thus, each chat participant was recognized by name. During the chats, students often referred to each other by first name. This recognition created a very professional working environment for the online chats.

The format of the chats consisted of a student(s) posting a specific question to the group. Other members of the class were then free to jump in and offer the student help and advice. If a student(s) fell off course in the discussion, the instructor would offer some guidance and attempted to steer the discussion back on track. Oftentimes the instructor made use of Socratic dialogue techniques during the chats. Hake [39] developed the Socratic Dialogue Inducing (SDI) lab method which combines interactive engagement teaching and learning strategies with various forms of hands-on experiences. The SDI method was the outgrowth of the work of Arons [40]. Much of Arons' work stemmed from studies of cognitive science and often blended ideas from scholars such as Socrates, Plato, Dewey, and Piaget. SDI labs have proven to be an effective way to guide students to a more solid conceptual understanding of Newtonian Mechanics [41]. Hake has suggested that the SDI method might be characterized as "guided construction" rather than "guided discovery" or "inquiry". Through the online chats the instructor encouraged guided construction by posing frequent, probing questions to the students. The instructor also used the chats to facilitate a "think out loud" protocol in which both the students and the instructor could offer assistance and guidance to a particular student's question or comment. This strategy appeared to be a very effective way to assist students in confronting their personal misconceptions about a particular topic or concept.

Typically, about 20 students would log into the online chats. This represented approximately 15 – 20 % of the total number of students enrolled in the PMW class. However, this number is potentially misleading, as many more students took advantage of the discussions generated during the chats. A unique feature of the Blackboard chats was that they were automatically archived online. This means that a student who was unable or chose not to log in and participate in the live chat, could access the archives at any time. Through informal discussions with students, the instructor determined that a much larger percentage of students were actually taking the time to look at the archives prior to completing their homework assignments. As a result, the quality of the homework papers submitted by many students during the semester was very high in comparison with the quality during previous semesters.

The use of online chats offered a relatively new avenue through which learners could take an active role in the learning process. Furthermore, the online chats could be viewed as one form of computer-assisted communication that promoted interactive engagement of the learner with the content being studied. In addition, the online chats offered some students a more comfortable environment in which to interact than the traditional large-lecture class. Although students were identified by name during the chats, the instructor worked to be sure that each student was treated respectfully. Students were very comfortable with the fact that their comments could be identified by name and never expressed any discomfort with this concept.

Certainly there are advantages as well as disadvantages associated with any form of computer-mediated instruction. This mode of communication has the potential to offer greater consistency and to enable students to improve their communication skills while engaging in problem-solving activities [42]. In addition, key differences between computer-mediated conversations and face-to-face discussions include: place dependence, time dependence, and structure and richness of communication [43]. However, if used as an additional learning tool, the online chats can offer students an alternative to traditional instruction and simultaneously appeal to a wider diversity of

learning styles [44]. In the section that follows, a brief synopsis of student perceptions regarding the two instructional approaches described is presented.

VII. STUDENT PERCEPTIONS OF THE LEARNING APPROACHES

Student perceptions regarding the two learning approaches highlighted in this paper were elicited through classroom surveys, as well as through informal communication between instructor and students. A summary of the results of several surveys regarding the folder activities given in recent semesters will be presented. These results will be shared in the form of typical student responses. Given that the Blackboard chats were first used in the fall 2002 semester, a survey was not conducted at that time. Thus, a summary of student feedback elicited through informal discussions will be shared. In future semesters, additional forms of assessment of student perceptions, as well as of student learning, will be employed.

Regarding the folder activity, students were asked whether or not they found that the written feedback they received had encouraged them to think more deeply about the physics concepts discussed in class. Some common student responses were:

- “It made me think more about the common sense behind the physics.”
- “With the amount of writing on the paper, and the fact that I knew you took the time to look at my work I knew that I needed to spend more time on my physics, but not necessarily on a specific concept.”
- “The feedback made me think more deeply about what I had written. The feedback on the **learning style** made me think more than the second one [folder assignment].”

In terms of the online chats, many students acknowledged that even if they had not logged into the live chats, they often made use of the archives when they were completing homework assignments. Several students indicated that the live chats, as well as the archived discussions, were so useful that participating was a “no-brainer!” In some cases, students requested a chat, which indicated that they genuinely found them valuable to the learning process.

Overall, the results of these surveys and informal discussions suggested that students found the writing and online chats beneficial and useful to them in some way. A fundamental difference between each of these learning approaches was the nature of the feedback students received. With the writing activities, students received feedback directly from the instructor. However, with the online chats, feedback was predominantly from students’ peers. These approaches, albeit quite different, provided students with diverse learning styles, alternative learning tools and strategies.

VIII. CONCLUSIONS

Acknowledgement of students’ individual learning styles played a critical role in the learning process for students enrolled in PMW in fall 2002. Furthermore, the use of formal learning-style assessments provided useful information that benefited the student as well as the instructor. Important to note was the fact that the learning style assessment tool used was not as critical as the actual assessment of learning styles. Through the specific teaching and learning strategies

that have been described in this paper, the value and importance of adopting a learning-style approach in the classroom has been illustrated. It is the contention of the author that the adoption of a learning-style approach increased student interest and motivation to learn, in part, through the development of alternative learning strategies designed to accommodate an increasingly diverse population of learners. The need to identify individual learning styles through formal assessment has never been more important than it is at present. Instruction responsive to individual learning styles is especially critical as the pool of students who enroll in introductory physics classes becomes more and more diverse.

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