Blackboard Technologies: A Vehicle to Promote Student Motivation and Learning in Physics

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Abstract

The Blackboard Learning System™, a Web-based server software system, is widely used on many college and university campuses today. This paper explores the use of the Blackboard system as a teaching and learning tool. Particular emphasis is placed on the online chat feature available through the Blackboard interface. During the fall 2002 pilot semester, students enrolled in an introductory physics course for non-majors at American University made extensive use of live, interactive, online chats through Blackboard technologies to complete homework and other assignments. The optional chats were peer-led and instructor-moderated. The instructor utilized a Socratic dialogue approach to help promote deeper understanding of key topics and concepts. To address, in part, the question of whether deeper understanding was achieved for students who participated in the chats, results from the Force Concept Inventory (FCI), a widely used multiple-choice, survey-type instrument to assess student understanding of basic mechanics concepts in physics, was used. Pre- and post-test gains are compared for active participants in the online chats as well as for the class as a whole to help ascertain student potential gains in understanding of mechanics concepts. Students' overall course grades are also used to assist in a comparison between learning gains for participants and non-participants in the online chats. In addition, links to student learning styles are explored to determine whether learning style could be a potential factor in terms of active participation in the online discussions. Highlights of student perceptions regarding the use of Blackboard technologies, particularly the online chats, are shared.

Introduction

Rapid advancements in the use of technology continue to proliferate in modern society and in academia in particular. These advancements suggest that the integration of technology into the learning process must be continuous and progressive. A growing body of research on adult learners further suggests that increased learning gains can be achieved when instruction is designed with students' learning styles in mind (Dunn, Bruno, Sklar, & Beaudry, 1990; Gordon, 1993; Larkin-Hein & Budny, 2001; Lenehan, Dunn, Ingham, Murray, & Signer, 1994; Nelson, Dunn, Griggs, Primavera, Fitzpatrick, Bacilious, & Miller, 1993; Ranne, 1996; Williams, 1994). 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 (Agogino & Hsi, 1995; Felder, 1996; Felder & Silverman, 1988; Harb, Olani Durant, & Terry, 1993; Hein & Zollman, 1997; Herrick, Budny, & Samples, 1998; Larkin-Hein, 2000; Sharp, Harb, & Terry, 1997). Attention to learning styles and learner diversity has also been shown to increase student interest, motivation, and achievement (Dunn & Griggs, 1998; Dunn, Thies, & Honigsfeld, 2001; Larkin, 2003).

A growing number of technology-based educational tools currently exist within the domains of science, technology, engineering, and mathematics, (STEM) education. The use of these tools is growing swiftly, both in as well as out of the classroom and laboratory. The use of technology-based educational tools has the potential to serve as a powerful resource to improve the educational process for students and teachers (Edwards, 1997; Hanna & Associates, 2000; Hanna, Glowacki-Dudka, & Conceição-Runlee, 2000; Linn & Hsi, 2000). Of additional importance is the fact that educational technology is only as good as the content it supports (Hein & Irvine, 1998a). Research has shown that the use of various technological tools can only be effective in promoting student understanding if they are used in a pedagogically sound way (Kulik, 1994).

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 could be adapted for use with other populations of students as well. Moreover, the use of various technologies such as online chats may serve to better accommodate a wider spectrum of student learning styles than does traditional instruction (Hein & Irvine, 1999). The underlying message is that a learning-style approach can be successfully applied with any population of students including majors as well as non-majors. This is true both within and outside of the confines of the traditional classroom environment.

This paper addresses, in part, 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 in this study will be provided. The instructional approach involving online Blackboard chats is discussed, especially as it relates to student learning in physics and student learning styles. Pre- and post-test assessment data collected from the Force Concept Inventory (FCI) as well as course grades are presented. A summary of links between student learning styles and this instructional approach is described. Student perceptions regarding this learning strategy are shared to help ascertain its effectiveness as a learning tool in physics. An important objective of this paper is to illustrate how a non-traditional teaching and learning tool, such as the use of online chats, may lead to enhanced student interest, motivation, and learning.

Description of the 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)*. PMW is a foundation course in the Natural Sciences portion of the General Education core of courses. Topics covered in this course typically include kinematics, Newton's Laws, conservation of momentum and energy, rotational motion, and fluid mechanics. 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 (Meyers & Jones, 1993). Often times this is known as a "teaching by telling" approach (Knight, 2002). From an instructor's point of view, a relatively large amount of information can be passed along to students in a limited amount of time with this approach. However, an extensive amount of educational research has shown that most students find that the "teaching by telling" approach is not effective. Students cannot digest and comprehend large amounts of material that has only been passively received. Wankat (2002) suggested that *content tyranny* occurs when instructors allow the need to cover content control the processes of teaching and learning in a course. Traditional instructional methods have also been shown to be inadequate in terms of promoting deep learning and long term retention of important physics concepts. A learner-centered classroom that focuses on an interactive, hands-on approach to learning oftentimes leads to deeper understanding of key physics content. Numerous interactive teaching strategies have been developed for the PMW course that serve to better accommodate students' needs and diverse learning styles (Hein, 1999). The PMW course further includes both a strong conceptual as well as a strong problem solving component.

At the time the pilot study was conducted, PMW was a 3-credit course and consisted of a lecture and a laboratory component. Students met twice a week for class sessions that were 75 minutes long. On alternate weeks, students met for a $2\frac{1}{2}$ hour laboratory. Following a review of the entire General Education curriculum during the past academic year, a university-wide decision was made to transform all foundation courses in the Natural Sciences portion of the core to 4 credits. The implication for PMW will be that in all future semesters students will perform a laboratory activity every week rather than every other week.

Attention to learning style and learner diversity began on the first day of class and continued throughout the semester. Before a more detailed discussion of the online chats can be outlined, particularly as they relate to student learning and student learning styles, a description of learning style and the learning-style model that was used in PMW will be presented.

Learning Style Described and Defined

Historically, certain theorists parented concepts that related to learning differences (Cronbach, 1967; Glasser, 1969; Skinner, 1996). However, while progress was made into forming a deeper understanding of how learning takes place, their work did not uncover what made the identical instruction effective for some and ineffective for others (Dunn, Thies, & Honigsfeld, 2001). Rather, their work only described how certain learners learn.

What exactly is a learning style? Several definitions of learning style currently exist. Keefe (Oregon School Council Study Bulletin, 1987) 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 (1990) 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 (1982) 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 (1990) indicated that an individual's learning style can be compared to her/his ability and is therefore not etched in stone at birth. Dunn (1986) further noted that a person's style can change over time as a result of maturation. Kolb (1984) 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 these 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 process of teaching and learning.

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 (Brandt, 1990; Dunn & Bruno, 1985; Dunn, Dunn, & Freeley, 1984; Hein, 1994; Lemmon, 1984; Perrin, 1990). 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.

At present there are several different learning style models in existence. While the definition of learning style varies somewhat from model to model, what is clear is that while there are similarities among the models, there are also important differences. Debello (1990) noted that most models are narrow in focus and involve only one or two variables. He indicated that some models are multidimensional, encompassing cognitive, affective, and psychological characteristics, and others are limited to a single variable, most frequently from the cognitive or psychological domain. He adduced the models of Dunn and Dunn (1972), Hill (1971), and the National Association of Secondary School Principals (Keefe, et al., 1986) were the only three that were truly comprehensive as each required the analysis of multiple variables. For the purposes of the current study, the Dunn and Dunn model was chosen.

Description of the Dunn and Dunn Learning Style Model

This section will focus on the learning-style model developed by Dunn and Dunn (1993) as shown in Figure 1. The Productivity Environmental Preference Survey (PEPS) learning-style assessment instrument developed by Price, Dunn, and Dunn (1990) will also be described.

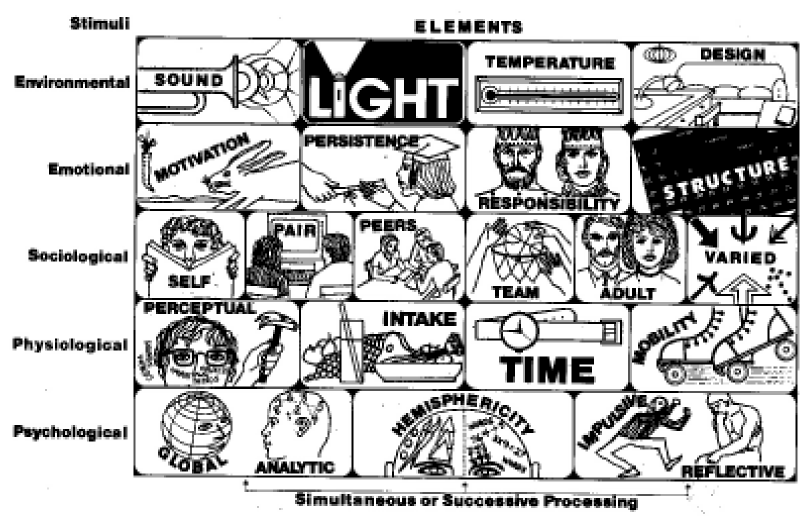


FIGURE 1.

The Dunn and Dunn Learning-Style Model

The Dunn and Dunn Learning-Style Model has had widespread use with adult learners. However its use in physics 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.

Price, Dunn, and Dunn suggested that productivity style theorizes that each individual has a biological and developmental set of learning characteristics that are unique. These researchers 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:

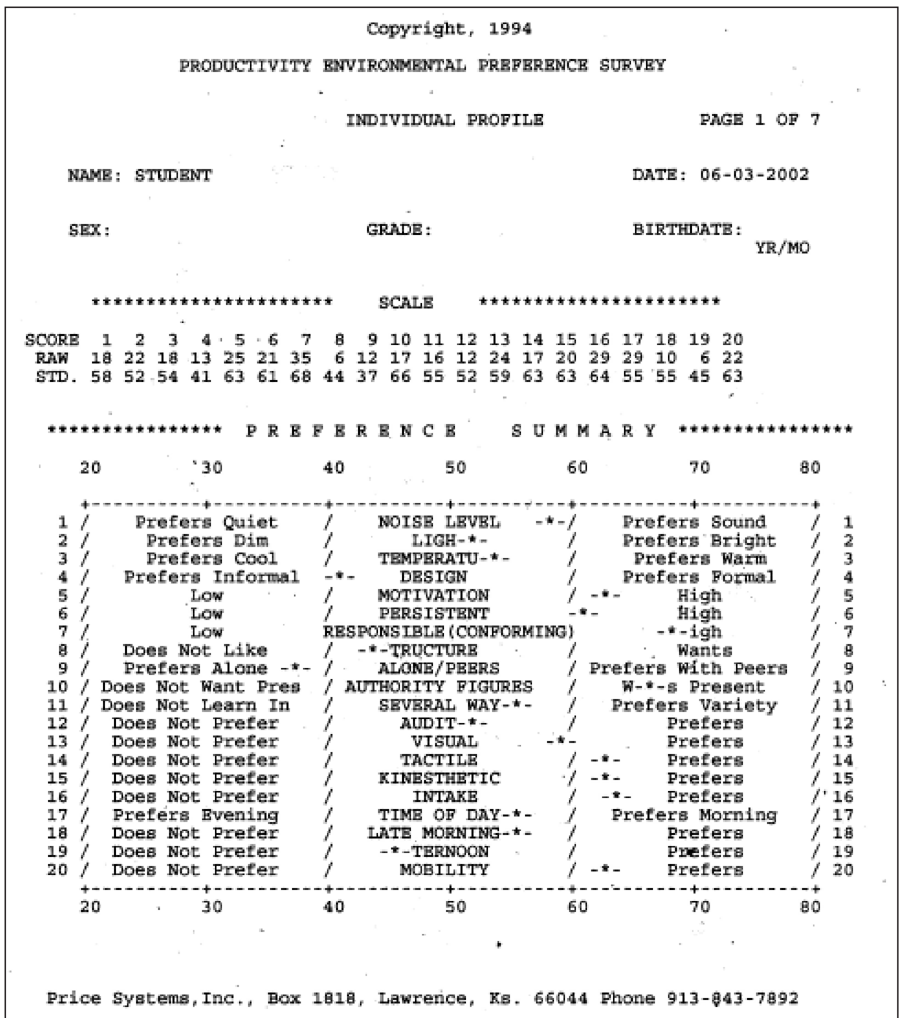
1) Most individuals are capable of learning.
2) The learning conditions in which different individuals learn best vary extensively.
3) Individual learning preferences exist and can be measured reliably.
4) Most students are self-motivated to learn when they have the option of using their learning style 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 too 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 use of online chats offers students an additional as well as non-traditional option as they work to learn key physics content.

The PEPS instrument by Dunn, Dunn, and Price was chosen for use in this study 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 summarized in the individualized feedback profile which is provided to each student after their responses to the PEPS have been scored.

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 categories. These categories are referred to here as Low, Middle, and High and are represented in the columns shown 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 may find that variable important when they are working and/or learning new and difficult information. 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. Important to note is the fact that motivation and interest can be directly linked to particular teaching and learn-



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                         Copyright, 1994

           PRODUCTIVITY ENVIRONMENTAL PREFERENCE SURVEY

                     INDIVIDUAL PROFILE               PAGE 1 OF 7

   NAME: STUDENT                                  DATE: 06-03-2002

   SEX:                      GRADE:               BIRTHDATE:
                                                            YR/MO

      **********************   SCALE   **********************

SCORE  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
 RAW  18 22 18 13 25 21 35  6 12 17 16 12 24 17 20 29 29 10  6 22
 STD. 58 52 54 41 63 61 68 44 37 66 55 52 59 63 63 64 55 55 45 63

 ****************  P R E F E R E N C E   S U M M A R Y  ****************

    20        30         40         50         60         70         80

    +----------+----------+----------+----------+----------+----------+
  1 /    Prefers Quiet    /    NOISE LEVEL   -*-/    Prefers Sound    /  1
  2 /     Prefers Dim     /      LIGH-*-        /    Prefers Bright   /  2
  3 /     Prefers Cool    /    TEMPERATU-*-     /     Prefers Warm    /  3
  4 /   Prefers Informal -*-     DESIGN         /    Prefers Formal   /  4
  5 /         Low         /    MOTIVATION       / -*-      High       /  5
  6 /         Low         /    PERSISTENT      -*-       High        /  6
  7 /         Low         RESPONSIBLE(CONFORMING)       -*-igh      /  7
  8 /   Does Not Like     /   -*-TRUCTURE       /         Wants       /  8
  9 /   Prefers Alone -*- /    ALONE/PEERS      / Prefers With Peers  /  9
 10 / Does Not Want Pres  / AUTHORITY FIGURES   /     W-*-s Present   / 10
 11 / Does Not Learn In   /    SEVERAL WAY-*-   /   Prefers Variety   / 11
 12 /  Does Not Prefer    /      AUDIT-*-       /        Prefers      / 12
 13 /  Does Not Prefer    /       VISUAL       -*-       Prefers      / 13
 14 /  Does Not Prefer    /      TACTILE        / -*-    Prefers      / 14
 15 /  Does Not Prefer    /    KINESTHETIC      / -*-    Prefers      / 15
 16 /  Does Not Prefer    /       INTAKE        /  -*-   Prefers      / 16
 17 /  Prefers Evening    /    TIME OF DAY-*-   /   Prefers Morning   / 17
 18 /  Does Not Prefer    /  LATE MORNING-*-    /        Prefers      / 18
 19 /  Does Not Prefer    /    -*-TERNOON       /        Prefers      / 19
 20 /  Does Not Prefer    /      MOBILITY       / -*-    Prefers      / 20
    +----------+----------+----------+----------+----------+----------+
    20        30         40         50         60         70         80

 Price Systems,Inc., Box 1818, Lawrence, Ks. 66044 Phone 913-843-7892
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FIGURE 2.

Results of the PEPS (reprinted with permission) ing approaches. If a student feels comfortable with and enjoys a certain approach, their motivation to learn can be enhanced.

Looking at one specific example, within the category of the environmental stimuli 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 greater than or equal to 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 less than or equal to 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.

Numerous research studies (Research Based, 1990) have documented the reliability and validity of the PEPS. Dunn and Dunn (1993) 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 (R. Dunn, personal communication, February 9, 2003).

Dunn, et al. (1995) 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 had been matched could be expected to be about three-fourths of a standard deviation higher than those of students whose learning styles had not been accommodated. Further, when instruction is compatible with students' learning style preferences, the overall learning process is enhanced.

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

Teaching and Learning: An Approach 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 maintained a copy of each student's profile and made use of that when working with individuals during office hours. The learning style profile was particularly useful when working with students that may have been having difficulties in the course. Students were quickly made aware that no high or low exists on this scale in terms of superiority of scores. Thus, no scores are either good or bad - all are simply unique. No scientific evidence exists which shows that one type of learning style is academically superior over another.

Teaching approaches utilized in the introductory physics course were designed, in part, using the Dunn and Dunn Learning-Style Model. The approach of particular interest here involves the employment of online chats using Blackboard technologies and is described in the following section.

Interactive Online Chats Using Blackboard Technologies

A notable teaching approach used with introductory physics students involved 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 other dimensions of the course. 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 could simultaneously satisfy their individual preferences within the environmental category. Furthermore, since the instructor participated in the discussions, students satisfied their preference to work with an authority figure present. In addition, students made use of writing, in electronic form, as they communicated with their classmates. When offered in a non-threatening fashion, such as with the online chats, writing can serve to help students elicit and confront their misconceptions in physics (Hein, 1999).

The use of online chats may also serve to enhance student motivation to learn. Furthermore, some students tend to shy away from participating in class discussions when class sizes are large. The chat environment may offer an additional, non-threatening venue for students to increase their understanding of physics while simultaneously allowing those who tend to be shy an alternative way to participate in class discussions. Because students are not actually talking with each other or the professor face-to-face, some of the pressure students feel talking aloud in a large class may be reduced.

The *Blackboard Learning System™* (Blackboard, Inc. 2002a) is a technology platform aimed at achieving several objectives including measuring and improving student performance, increasing instructor productivity, and enabling "Web-enhanced" classroom-based teaching and learning (p. 3). This system also features an online environment that has been designed to supplement either traditional learning or distance learning. Through an intuitive interface, instructors manage online environments for teaching and learning using the following utilities which include content management and content sharing, assessment management, collaboration and communication, assignment and portfolio management, and an online grade book (p. 4). Some of these features can be tracked by an instructor to determine how many students are actually accessing the site and downloading homework assignments, etc.

Blackboard Inc. recently announced the charter release of the *Blackboard Learning System ML™* in Brazilian Portuguese in October 2002 (Blackboard, Inc. 2002b). The *Blackboard Learning System ML™* is a multi-language edition of the company's market-leading course management system. Other languages available through this system include Chinese, French, German, Japanese, Spanish, and English. In addition, others including Dutch, Italian, and Korean are currently being developed. Thus, the global nature of this learning environment has broad ranging potential for use at the international level as well.

The particular feature to be explored here involves the collaboration and communication utility of Blackboard. During the fall 2002 pilot semester all students in PMW were enrolled in a course-specific Blackboard site. Students had immediate access to course documents such as syllabi, assignments, and other classroom material. 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), commonly used by students to chat via the internet (http://www.aim.com/index.adp (accessed 01/10/03)). 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 all chat using a single screen as shown in Figure 3. This feature allowed for a continuous discussion to take place between everyone logged into the chat.

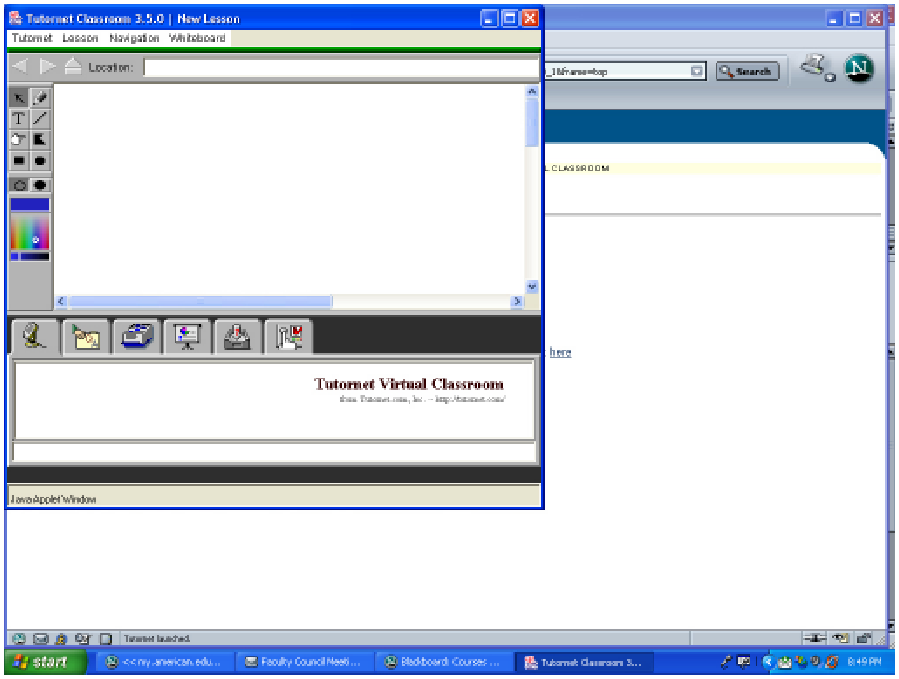

FIGURE 3.

The Blackboard Chat Screen

In addition to the chat feature, the chat screen also includes a white board where the students and the professor can draw and label pictures and diagrams, which is very useful in a physics class. The use of the white board allowed for substantially richer and more robust discussions.

The online chats provided a useful way of facilitating immediate peer-, as well as instructor-given feedback. The online chats have further proven to help students elicit and confront their misconceptions (Hein & Irvine, 1998b). The most common use of the chats was for the discussion of questions related to homework and laboratory assignments. 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. During the chats, students often referred to each other by first name. Rather than posing a threat or intimidating the student participants, the personalized identification created a very professional and collegial environment for the 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 offered some guidance and attempted to steer the discussion back on track. Oftentimes the instructor made use of Socratic dialogue techniques during the chats.

Hake (1992) 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 Arnold Arons (1990), one of the pioneers in physics education research. 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 (Hake, 1998a). 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, anywhere from about 2 - 20 students would log into the online chats at a given time. 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 meant that a student who was unable or who chose not to log in and participate in the live chat, could access the archives at any time after the chat had taken place. Only the text portion of the chats was archived, so anything placed on the white board during the discussions was not able to be viewed later through the archives. The instructor was careful to make sure that anything placed on the white board during a chat was carefully described in the text so that anyone viewing the archives later would have a clear picture of what was discussed. In addition, while some features of Blackboard can be tracked by an instructor, the archives, at present, cannot be tracked. Thus, an instructor does not currently have the ability to easily determine how many students are actually accessing the archives after a chat has taken place. 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 appeared to be quite high in comparison with the quality during previous semesters.

The following section provides a summary of the data collected in this study. In addition to the data gathered to assess student learning, links between instructional approach and learning styles will be shared.

Assessment of Student Learning

In fall 2002, 113 students (56 females, 57 males) distributed between two lecture sections, were enrolled in the physics course. Complete data was not available for 13 of these students. Thus, the data presented include the 100 students (52 females, 48 males) for which a complete data set was available. Of this number, 35 students (roughly 33%) actively participated in the online chats. A breakdown by gender reveals that this group consisted of 23 females and 12 males.

By the end of the fall 2002 semester, 13 online chats had been conducted. Of the 35 active participants, the female students participated in an average of three chats while the male students participated in an average of two chats. Of interest is the determination of how participation in the online chats may have contributed to student learning. Note that for purposes of this study, a participant is considered to be one that took part in the live chats. Likewise, a non-participant is considered to be one that did not participate in the live chats. One measure of student learning was made through the use of the Force Concept Inventory (FCI). The FCI as an assessment instrument is described in the following section.

The Force Concept Inventory (FCI) and Course Grades

A number of assessment tools currently exist in physics education such as the Force Concept Inventory (FCI) (Hestenes, Wells, & Swackhamer, 1992), a widely used multiple-choice survey-type instrument to assess student understanding of basic mechanics concepts in physics. However, student responses on the FCI and other similarly structured instruments may not necessarily give an accurate picture of students' true mental models regarding particular concepts in physics. In a recent study using open-ended responses to the traditional FCI questions, Rebello and Zollman found that the distractors used on the FCI did not always reveal students' conceptual difficulties with a given question (Rebello, 2001). Furthermore, this study showed that when writing was used as an assessment of student learning, the window into students' understanding became clearer. Instruments such as the FCI are just one aspect of assessment and evaluation and just one mechanism by which student learning gains were assessed in this study.

All students in the physics course were administered the FCI at the beginning and at the end of the fall 2002 term. The FCI consists of 30 multiple-choice questions that probe for understanding of basic concepts of Newtonian Mechanics in a way that is understandable to the novice who has never taken a physics course, while simultaneously being rigorous enough for someone who has.

Studies conducted by Hake (1998b) of many physics classes nationally, suggest that an appropriate figure of merit for success on this test is the fraction of possible gain obtained as given in Equation 1:

$$\langle g \rangle = \frac{\text{(post-test average)\% - (pre-test average)\%}}{\text{(100 - pre-test average)\%}} \qquad (1)$$

As reported in Hake's study of 62 introductory physics courses (N = 6542), 14 "traditional" courses (N = 2084) achieved an average gain of 0.23 ± 0.04, while 48 "interactive engagement" courses (N = 4458) achieved an average gain of 0.48 ± 0.14.

The data for the fall 2002 PMW class shown in Table I reveals an average gain of 0.27 for the class as a whole (N = 100). Note that this number reflects the fact that 13 students did not complete both the pre- and post- tests so data were not available for those individuals. Interestingly, the average gain for females was significantly lower than the average gain for males. Furthermore, the average gain for females (.25) falls within Hake's average for a "traditional" class while the average gain for males is higher (.35).

TABLE I

FCI Results For Entire Class

Gender	Pre-test	Post-test	Gain <g>
F (N = 52)	9.85 (33%)	14.58 (49%)	.25
M (N = 48)	12.75 (43%)	18.17 (61%)	.35
Total (N = 100)	11.24 (37%)	16.30 (54%)	.29

Of additional interest is the comparison of the average gains made by the class as a whole to the average gains made by those students who actively participated in the online chats as well as to the average gains made by those students who did not. As shown in Table II, the average gain for this group (N = 35) was 0.27, which is close to that for the class as a whole.

TABLE II

FCI Results For Participants in Online Chats

Gender	Pre-test	Post-test	Gain <g>
F (N = 23)	9.74 (32%)	13.91 (46%)	.21
M (N = 12)	14.08 (47%)	20.08 (67%)	.37
Total (N = 35)	11.23 (37%)	16.03 (54%)	.27

Interestingly, the average gains for the female students who actively made use of the chats was not as high (.21) when compared to the average gain for all females in the class (.25). However, both average gains fall within Hake's average for a traditional class and cannot be considered significant. A comparison of the average gain for male students who actively participated in the chats was slightly higher (.37) than for the average gain for all males in the class (.35). It is possible that the Blackboard chats were slightly more helpful for males than for females in terms of enhancing their understanding of basic mechanics concepts as revealed by the results of the FCI.

Table III shows the results for those students who did not actively participate in the online chats. This data may not be very revealing because of the fact that a non-participant is simply defined as one who did not actively participate in the chats. These individuals very likely could have made use of the archived chats when completing their homework assignments.

TABLE III

FCI Results For Non-Participants in Online Chats

Gender	Pre-test	Post-test	Gain <g>
F (N = 29)	9.93 (33%)	15.10 (50%)	.27
M (N = 36)	12.31 (41%)	17.53 (58%)	.34
Total (N = 65)	11.25 (37%)	16.45 (55%)	.31

A comparison of the FCI results between active and non-active participants may suggest that the Blackboard chats did not significantly aid students in their understanding of basic mechanics concepts. For example, looking at each group as a whole, the average gain for active participants was lower (.27) than the average gain for non-active participants (.31). These results do not show a large difference in the gains achieved between groups, and therefore do not permit a firm conclusion to be drawn. One possible explanation of these results may be that those students (especially females) who made use of the chats were primarily those who had identified themselves as individuals needing more help in the course. An additional explanation may be that the Blackboard chats were more appealing to certain students with particular learning styles than to others.

While interesting, the results presented for the FCI are only a small aspect of the assessment of student learning. Of additional interest is the comparison of course grades for the class as a whole and for those who actively participated in the chats as well as for those who did not. This data is presented in Tables IV - VI.

The data shown for the class as a whole reveal the fact that while the female students had significantly lower average gains on the FCI, they had slightly higher GPAs than their male counterparts. Interestingly, a study conducted by McCullough (2002) involving non-majors in introductory physics revealed significant gender differences on FCI scores. These differences may be a result of some inherent gender bias in the instrument and may not completely reveal actual understanding of basic mechanics concepts.

The data does indicate, however, that the average grade of students who actively participated in the chats was slightly higher than for the class as a whole. When broken down by gender, however, the data show that the average grade for female chat participants was slightly lower (3.03) than that for female non-participants (3.08). For the male students, the difference is more notable. The average grade for the male participants was 3.17 while the average grade for male non-participants was 2.93, which represents a difference of 0.24. The results shown here raise an important question. Did the use of the Blackboard chats have a more positive impact on male students than on female students in terms of the learning of key physics concepts? These results may suggest that additional research is needed to uncover possible reasons for the apparent gender differences in FCI results as well as in course grades, especially as they relate to the use of interactive online chats and student learning styles.

Learning Style Assessment

The most revealing assessment of students' learning styles as they relate to participation in the chats and to learning gains would be to look at each profile individually. Because of the relatively large number of students in PMW during fall 2002, this analysis is not provided here, but will be the subject of a separate paper. However, it is instructive to look at some learning style elements as they relate to some specific preferences of those students who chose to participate in the chats.

In terms of individual learning styles, it is important to ascertain what factors might serve to motivate students to participate in the online chats. Inspection of the learning style assessment results for the students who did actively participate reveals that these students shared a common preference for learning with an authority figure present. In addition, the assessment results suggest that almost all of these students had middle to high scores on the tactile and visual components of the assessment. The online chats required a great deal of hands-on interaction as the students typed up their responses and questions. Furthermore, students had to visually interact with the discussion material through the use of their computer screens.

While more difficult to assess, other learning style elements that may have contributed to using the chats are those in the environmental category. Students could choose the type of environment they wished to be in when they logged into the chats. An additional element worthy of further exploration is the time of day element. Because the time for the chats was intentionally varied, this may have encouraged more students to participate. Furthermore, because the chats are archived, all students (active and non-active) had access to the discussions at any time of the day or night. Because the archived information was available day or night, this allowed students to pursue their work through their individual time of day preferences.

It may also be useful to look briefly at one piece of correlational data as it relate to students' learning style preferences and course grades. For example, students who actively participated in the chats had a slightly higher preference for structure than non-participants. A stronger correlation between course grade and the structure element (r = .35) existed for participants than between course grade and structure for non-participants (r = .07). When broken down by gender, correlations for chat participants between course grade and structure were much higher for males (r = .57) than for females (r = .24). This is more interesting in light of the fact that course grades for male participants were 0.24 higher than for male non-participants. It is possible that the Blackboard chat environment may serve to provide additional needed structure for those students who participated (especially the male students), thus, better accommodating their individual learning style preferences. Additional research is needed to determine if the Blackboard chat environments offers more apparent structure for male students than for female students.

Gender	Average Grade
F (N = 52)	3.06
M (N = 48)	2.99
Total (N = 100)	3.03

TABLE IV
Course Grades For Entire Class

Gender	Average Grade
F (N = 23)	3.03
M (N = 12)	3.17
Total (N = 35)	3.08

TABLE V
Course Grades For Chat Participants

Gender	Average Grade
F (N = 29)	3.08
M (N = 36)	2.93
Total (N = 65)	3.00

TABLE VI
Course Grades For Non-Participants

Student Perceptions of the Learning Approaches

Student perceptions regarding the learning approach used during this pilot semester were elicited primarily through informal communication between the instructor and students as well as from student evaluations of the course. In future semesters, additional forms of assessment of student perceptions, as well as of student learning, will be employed to further ascertain the pedagogical effectiveness of this approach.

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.

Additional queries will be undertaken in future semesters to determine how those students who didn't actively participated in the chats made use of the archived discussions. Tracking student use of the archived chats would add richness to the data gathered thus far, and may provide some additional insight into the apparent gender differences noted here.

Inspection of the course evaluations reveals a significant number of students who made use of the online chats. Typical comments from students were that the online chats and the associated archives were enormously helpful to them as they completed their homework assignments. The large number of students who positively commented on the use of Blackboard technologies in the course suggests that many students (both active and non-active participants) made use of the chat feature and/or the archived discussions.

Overall, the results of the informal discussions and course evaluations suggest that students found the online chats beneficial and useful to them in some way. Unique to the chats was the nature of the feedback that the students' received. With the online chats, feedback predominantly came from students' peers. This approach provided students with diverse learning styles an alternative venue for learning.

Conclusions

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 learners with the content being studied. In addition, the online chats may have offered some students a more comfortable environment in which to interact rather 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 (Phillips & Santoro, 1997). Key differences between computer-mediated conversations and face-to-face discussions include: place dependence, time dependence, and structure and richness of communication (Harasim, 1990). 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 (Irvine, Hein, & Laughlin, 1999).

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. It is the contention of the authors 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.

The use of interactive online chats may offer an additional venue through which individual learner preferences can be accommodated. Through the pilot study described, this paper offered one view of how online chats can be used to promote and enhance student learning. As the Blackboard system itself becomes increasingly sophisticated, additional tools are expected to become available (M. Stanton, Blackboard Inc., personal communication, November 25, 2003). For example, having the opportunity to track the number of students viewing the archived discussions would allow additional and more in-depth study of how individual learning styles may be linked with the use of the chats, both live and online, as well as through the archived discussions. The current study suggests that further investigation of the chat feature of Blackboard and its potential links to individual learning styles would provide additional insight into how this powerful learning tool may best be utilized to promote student learning.

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