INSTITUTE FOR Learning Styles RESEARCH

Institute for Learning Styles Research Journal

Volume 1, Fall 2008

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Volume 1, Fall 2008

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Learning Styles and Students' Attitudes Toward the Use of Technology in Higher and Adult Education Classes

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Abstract

The purpose of this research was to examine students' attitudes toward the use of technology and to determine if attitudes toward the use of technology differ based on learning style. Lukow's Attitude Toward the Use of Technology Survey (ATUTS) measured attitudes toward the use of technology, and learning styles were measured using Kolb's Learning Style Inventory (LSI). The participants of the study were enrolled in Higher and Adult Education (HIAD) courses in the summer and fall semesters of 2004 in the Department of Leadership at The University of Memphis. A one-way analysis of variance (ANOVA) was used to determine if attitudes toward the use of technology differed for participants based on learning style. The results of the ANOVA showed no significant findings, which demonstrates that in the population for this study, no relationship existed between attitude toward the use of technology and learning style.

Introduction

Education today is faced with the challenge of adapting to an environment of ever increasing technological advances. The challenge for educators is to utilize this technology in ways that facilitate the highest level of learning outcomes. The educational community has growing concern about the effectiveness of technology such as CD-ROM, videotapes, multimedia presentation software, World Wide Web (WWW) discussion forums, and the Internet to meet the needs of students when utilized in the classroom (Lukow, 2002). Thus, it can be said that while technology use in the classroom is copious, improving learning through the application of this technology should remain the goal.

There are several issues that may arise when applying technology in the classroom. Among these are (a) choices about which technology to use (Bascelli, Johnson, Langhorst, & Stanley, 2002), (b) how effective technologies are in reinforcing learning (Grasha, 1996), and (c) technology's role in shifting from an instruction paradigm, which is teacher focused, to a learning paradigm, which is student focused (Van Dusen, 1997).

Shifting the classroom perspective from teachers to students must involve recognizing learning styles of students. Subsequently, teachers must adjust teaching strategies to accommodate different styles. Given the amount of literature about how "learning style" is actually defined, the following definition addresses the role of the individual in learning. Learning style can be defined as the general tendency towards a particular learning approach displayed by an individual (Keefe & Ferrell, 1990; Robotham, 1999). In other words, students may prefer one approach to learning over other approaches.

If the goal of educators is to increase learning outcomes, addressing the issues involved in using technology in the classroom and accommodating student learning styles must be examined. Although there are studies addressing the issues of technology integration into the curriculum and the attitudes of students toward the technology being used, there is limited research that links these attitudes to individual learning styles (Lukow, 2002).

Problem Statement

The problem examined in this study is whether the attitudes toward the use of technology of students enrolled in Higher and Adult Education (hereafter referred to as HIAD) courses at the University of Memphis differ based on their learning style preference. Further, students' attitudes toward the use of technology in HIAD courses can offer insight into such questions as whether to use technology in the classroom. The results of this study will be generalizable to graduate students in Higher and Adult Education courses at the University of Memphis.

1. What are students' attitudes toward the use of technology in HIAD courses?
2. Do attitudes toward the use of technology in HIAD courses differ for Kolb's four categories of students' learning styles?

Purpose of the Study

The purposes of this study were to examine student attitudes toward the use of technology in higher and adult education courses and to specify any differences in attitudes based on students' learning styles. Further, this study adds to the research about the relationship between attitude and learning style. The findings of this study can be compared to and perhaps increase the generalizability of a study done by Jennifer Lukow in 2002 at Indiana University. Lukow (2002) contends, "If correlations are found between the learning styles of students and how these relate to their [students'] attitudes toward technology, then instructors may feel fairly confident that they can use such instruments to appropriately gauge how to approach teaching a course with reference to instructional technologies" (p. 4).

This study can also be useful in aiding the education community about the technology choices students prefer based on their use of these technologies, and which technologies are not preferred. Seeking appropriate technology choices based on learning style will serve to produce more desirable learning outcomes. Teaching students based on their preferred learning style significantly increases their achievement level (Dunn, Deckinger, Withers, & Katzenstein, 1990). Thus, the use of technologies that match students' preferred style of learning may have a positive impact on educational outcomes.

Significance of the Study

Results of the study may contribute to the information available to educators about the use of technology in the classroom. Additionally, information about the importance of adjusting the use of technologies to accommodate the differences in learning style from student to student may be determined. There is a need for educators to understand students' attitudes toward the use of different types of technology as well as how these attitudes are related to their learning style. Determining the value of technology in the classroom is one of the most controversial issues challenging education today. Part of this challenge is understanding how technology lends itself to student learning.

Infusing technology into the curriculum can offer valuable lessons to educators as to what is appropriate in facilitating learning. Lessons learned when using technology in the classroom can be a) you can have too much technology in your classroom, b) technology can be intimidating if students have not been uniformly prepared prior to its use, c) students can be unforgiving if technology fails, d) in many instances, the process is more important than the product developed using technology, and e) technology can affect teaching style. Technology cannot teach, only teachers teach, and the tools for technology do not always enhance learning (Richards, 1999). Moreover, Richards suggests that it is necessary to continually reflect, evaluate, and adjust instruction when using technology (1999, p. 4).

In the last ten years, the World Wide Web and technology have become increasingly pervasive in higher education, yet little empirical evidence has been generated to demonstrate the connections between students' learning styles and the use of this technology. It is becoming increasingly clear that technology, in and of itself, does not directly change teaching or learning (Lukow, 2002). Rather, the critical element is how technology is incorporated into instruction. This integration of technology is so expansive across all areas of education that research is needed to explore the connections between its use and how students respond to its use in the classroom.

Literature Review

With technology advancing at an increasing rate, it is necessary to understand how it shapes or influences the learning process. As an ever-present component in higher education pedagogy, more empirical evidence is needed to demonstrate the connections between students' preferences for learning and the use of this technology. The review of this literature will seek to a) explain four categories of learning styles as well as describe learning style, b) explore technology and its role in the classroom, and c) discuss students' attitudes toward technology.

Learning Styles

"Perhaps the most vital development in American education today is the concept of individual learner's preferences" (DeBello, 1990). This contention is widely supported by further study (Green & Parker, 1989; Kirkpatrick 1983; Miller & Rose, 1975) addressing the importance of learning style associated with learning outcomes. One particular way of organizing research on learning styles is that of Curry (1983). Curry's categorization of learning style research is analogous to the layers of an onion; each of these layers is a person's characteristics that make up "style" (p. 7). The four layers of this "onion" are described as a) instructional preferences, b) social interaction, c) information processing, and d) personality. For purposes of this study, the information processing models are examined.

Information Processing Models

Information processing models are those that assert the importance of understanding of how information is obtained, sorted, stored and utilized (Curry, 1983). One such model that emphasizes information processing as key to learning is Howard Gardner's Theory of Multiple Intelligences (1983). Gardner proposes that there are eight intelligences that describe the way in which people process information and names them in terms of the learner (Gardner & Hatch, 1989). The linguistic learner learns best by saying, hearing, and seeing. This type of learner likes to read, write, and tell stories; he/she is sensitive to the influence or words and languages on others. The logical/mathematical learner learns best by categorizing, classifying, and working with abstract patterns/ relationships. This type of learner also likes to do experiments, figure things out, work with numbers, ask questions, and explore patterns and relationships, and is good at math and logic.

The visual spatial learner learns best by visualizing, dreaming, using the "mind's eye", and working with colors/pictures. This type of learner likes to draw, build, design and create things, daydream, look at pictures/slides, watch movies, and play with machines. He/She is good at imagining things, sensing changes, mazes/puzzles, reading maps and charts.

The musical rhythmic learner learns best by rhythm, melody, and music. He or she is good at picking up sounds, remembering melodies, and keeping time. He or she also likes to sing or play an instrument. The bodily/kinesthetic learner learns best by touching, moving, and interacting with others, and is good at physical activities.

The interpersonal learner learns best by sharing, comparing, and relating. This type of learner processes the world outside herself/himself, and is comfortable is everyone else is comfortable. This type of learner is also good at understanding people, is good a leading others, and mediating conflicts. The intrapersonal learner learns best by working alone, likes individualized projects, and having their own space. This type of learner is self-attuned and is good at focusing inward on feelings and dreams. Also, this learner processes the world inside himself and talks only when necessary. The last of the eight types based on Howard Gardner's work is the naturalistic learner. This type of learner learns best by identifying and categorizing. The naturalistic learner also likes to organize, collect, sort and recognize based on appearance, texture, and sounds.

These multiple intelligences described by Gardner offer a framework for which the processing of information can be explained. These eight categories of learning styles can be applied to the processing of information from many sources, thus aiding educators in understanding that students are likely to process information in several ways. Another information processing model is that of Kolb (1984). Kolb's model and self-assessment are based on experiential learning theory that emphasizes the need of learner involvement in educational activities. Life experience is a major influence in how the learner obtains, sorts, stores, and utilizes information.

Kolb (1984) describes learning as a four-step process that includes a) concrete experience, b) reflective observations, c) abstract conceptualization, and d) active experimentation. Concrete experience is the feeling component of taking in information whereby learners involve themselves fully in the experience and then reflect on the experience. These reflective observations (watching) are where the learner is able to see a concrete experience from other perspectives. Next, engaging in abstract conceptualization (thinking) is where the learner creates "generalizations or principles that integrate their observations into sound theories" (p. 26). Finally, active experimentation (doing) is where the learner takes these theories and generalizations and tests what they have learned in new ways.

Kolb further states that knowledge "results from the combination of grasping experience, and transforming it" (p. 41). The grasping of information is taking in information. Kolb contends that some learners prefer to take in information through concrete experience, while others prefer to take in information through abstract conceptualization. The processing of information (transforming) occurs through reflective observation or active experimentation.

Kolb's theory is based on a model with two dimensions. The first dimension is "taking in" and runs vertically with "feeling" at the top, and "thinking" at the bottom. The second dimension is "transformation" or "information processing" and runs horizontally with "doing" on the left, and "watching" on the right. These four polar opposites are called learning modes. These learning modes are a) Concrete Experience,

b) Reflective Observation, c) Abstract Conceptualization, and d) Active Experimentation.

The intersection of the two dimensions results in the designation of the four learning styles. The theory asserts that each of us has a preference for comprehending and transforming, and the combination of these preferences is called our learning style. A learner who prefers concrete and reflective has a "diverging" learning style. A learner who prefers abstract and reflective has an "assimilating" learning style. A learner who prefers abstract and active has a "converging" learning style. A learner who prefers concrete and active has an "accommodating" learning style.

Learning Styles and Technology

The new axiom in the world of technology-enhanced learning is that teachers must allow content to drive technology and should be cautious not to let technology drive the content. The goal is to use tools that are appropriate to the needs of the learning experience (Gynn, 2001). There should always be good reason for including technology in the learning environment. Gynn points out that technology can be the tool that connects the student to knowledge, the student to other students, and the student to the teacher.

One of the questions that Gynn sought to answer was "How do we address learning styles?" She contends that to address the multiple learning styles in any classroom, the principles of sound pedagogy are at the forefront. One way to do this is to incorporate a variety of learning activities to accommodate different learning styles. This will help students expand their learning style experience. According to Gynn, it is also important to consider student access to and comfort with current technology and software packages. While comfort with using technology is separate from learning style, it affects learning, and making sure all students are comfortable with the technology is important in accommodating diverse learning styles, especially those taking online or distance education courses. Several studies were reviewed which elucidate the importance and/or implications of the usefulness of technology in regards to learning styles. These range from multimedia software to online distance education.

Montgomery (1995) conducted a study at the University of Michigan which investigated the issue addressing diverse learning styles through the use of multimedia. A survey of learning styles was conducted in a sophomore level introductory chemical engineering class with an enrollment of 143 students. Early in the semester, one class was devoted to the topic of learning styles. The author contends that one of the challenges of teaching engineering, or any other discipline, is trying to meet the needs of a variety of students (Montgomery, 1995). She asserts that this is particularly challenging in large classes, where the typical teaching mode is heavily dependent on lectures. One way to meet the needs of all the students individually is through the use of educational software; specifically multi media based software, in meeting the diverse needs of learners.

Buerck, Malmstrom, and Peppers (2003) of St. Louis University conducted a study entitled "Learning Styles and Learning Environment." The study examined student success in an internet-based versus a lecture based computer science course. Success in the courses was determined by final grade and learning styles were assessed using David Kolb's Learning Style Inventory. Since many colleges and universities are increasingly using information technologies to enhance the learning environment, many institutions are offering internet-based online courses in an effort to meet the educational needs of a diverse student population. The authors' primary goal was to determine a relationship between students' preferred learning environment (online or face to face), and their learning style. Another goal was to determine if there were any differences in the academic success in the students in the face-to-face versus the online sections of a course.

The participants in the study were adults (22 years and older), non-traditional computer science students who were given the option of taking a face-to-face lecture-based course or an online Internet based course. The results of the study showed that computer science students in the face-to-face learning environment were more likely to have the assimilating learning style, whereas computer science students in the online course were more likely to have the converging learning style. Student academic success did not differ significantly because of learning environment selection.
In 1993, Gunawardena and Boverie adapted David Kolb's experimental learning theory and Learning Style Inventory, and studied the interaction between adult learning style and computer-mediated classes compared with non-equivalent traditional classes. Specifically, they focused on the interaction between learning styles and the media, methods of instruction, and group functioning in a distance learning class using audio and graphics. They found that learning styles do not affect how students interact with media and methods of instruction, but they do affect satisfaction with other learners, with Accommodating learners being the most satisfied and the Diverging learners being the least satisfied with class discussions and group activities.

Sein and Robey (1991) also used Kolb's LSI to study the interaction between learning style and usefulness of computer training methods. They concluded that Converger participants who combine active experimentation and abstract conceptualization perform better than participants with other learning styles do. This suggests that student learning outcomes when using computer application software may be affected by the learning style, regardless of the training methods. However, in an effort to seek the relationships between learning style preference and the effectiveness and acceptance of interactive video instruction, Larson (1992) found no significant differences between learning style groups and suggested that both effectiveness and satisfaction are independent of students' learning style preference. All these studies provide information about different ways in which technology- enhanced learning takes place, and its significance in increasing learning. The implication is that the use of technology and technology-enhanced learning can and should be used in such a way as to engage students relative to their preference for the way in which they learn.

Methods

This study sought to examine the attitudes of students toward the use of technology in higher and adult education (HIAD) courses at the University of Memphis. Also, the study explored the differences in students' attitudes based on their individual learning styles. Attitudes toward the use of technology were measured using Lukow's Attitude Toward the Use of Technology Survey (ATUTS), and learning styles were measured using the Kolb Learning Style Inventory (LSI). This section of the study is organized as follows: arrangements for conducting the study, selection of the participants, instrumentation, data collection, and data analysis.

Students enrolled in the Department of Leadership at the University of Memphis were the population from which the participants were chosen. Specifically, all graduate courses offered in Higher and Adult (HIAD) education were the total population. This included all sections offered during the summer and fall semesters of 2004. Every course offered during these semesters was used due to the variance in amount of technology used in the classes. These courses included Master's and Doctoral students who were the focus of the study and only those who volunteered to participate were used as participants. Students who were enrolled in more than one of the offered classes were asked to participate in the study only one time.

Students enrolled in HIAD courses in the Department of Leadership received a packet of information that included: Study Information Sheet, the Kolb Learning Style Inventory, and the Attitude Toward the Use of Technology Survey. Each of the items in the packet contained a number written on the top right corner in order to ensure the responses of each student are kept together. Also, this ensured that the students responses to the LSI and the ATUTS be compared appropriately. The packets were distributed to the participants either at the beginning or the end of each class period. The information sheet included enough information about the study so that each participant could make an informed decision regarding whether they wished to participate in the study. The completion of both instruments took 15-20 minutes.

Data analysis was conducted using the information gathered on the Kolb Learning Style Inventory and the Attitude Toward the Use of Technology Survey. The instruments were checked to see if they were completed accurately. The first analysis of the data answered the research question: What are students' attitudes toward the use of technology in HIAD courses? The first analysis was a description of the data gathered from the Attitude Toward the Use of Technology Survey. A similar descriptive analysis was used to describe the data from Kolb's LSI. In order to answer the research question, "Do attitudes toward the use of technology in HIAD courses differ for the four learning styles?" a one-way analysis of variance (ANOVA) was performed on the learning styles in order to discover any differences in respondent attitudes toward the use of technology. The dependent variable (DV) was attitude toward the use of technology. The independent variable (IV) was learning style that has four categories; Diverging, Accommodating, Assimilating, and Accommodating.

Results

A One-way Analysis of Variance (ANOVA) was used to examine whether students' attitudes toward the use of technology is a function of their learning style. The independent variable represented the four different learning styles (Diverging, Assimilating, Converging, and Accommodating). The dependent variable is attitude toward the use of technology (Range: -60 to +60). Table 1 entitled "Range of Attitude for Learning Style" identifies the means, standard deviations, and minimum and maximum attitude score for each of the four learning styles. Respondents with "Converging" learning style had the most favorable attitude toward the use of technology (*M* = 32.16). Respondents with a "Diverging" learning style had the lowest attitude toward the use of technology (*M* = 24.21).

Table 1
Range of Attitude for Learning Style

Learning Style	*f*	Mean	*SD*	Min.	Max.
Diverging	24	24.21	17.33	-14	54
Assimilating	41	24.90	12.91	-8	50
Converging	25	32.16	13.10	11	49
Accommodating	12	25.25	7.25	11	34

An alpha level of .05 was used for all analyses. The test for homogeneity of variance was not significant [*Levene* (3, 98) = 2.64, *p* = .054] indicating that this assumption underlying the application of ANOVA was met. The one-way ANOVA of students' attitudes toward technology revealed a statistically non-significant main effect [*F* (3, 98) = 1.88, *p* = .139] indicating that the four groups (learning styles) did not differ in their attitude toward technology (see Table 2).

Table 2
Analysis of Variance for Learning Style

Source	*SS*	*df*	*MS*	*F*	*p*
Between	1049.97	3	349.99	1.88	.139
Within	18281.18	98	186.54		
Total	19331.15	101			

Discussion

This study was conducted to determine if a relationship existed between students' learning styles and their attitude toward the use of technology. In order to identify any differences among learning styles with relation to the Total Attitude Score, a one-way ANOVA was conducted. The results of the ANOVA showed no significant results. This demonstrates that there is no relationship between attitude toward the use of technology and students' preferred learning style. Further, the non-significant results support Lukow's (2002) contention that no matter how a student prefers to learn, the students may have been previously exposed to sufficient levels of technology, and have developed their attitude toward technology long before they entered the Higher and Adult Education program. This may be true particularly with this sample given the age range of the respondents. A total of 52% of the respondents were in the age category of 21-35 years of age.

Another possible explanation for the non-significant results of this ANOVA is that the Higher and Adult Education program may attract students who are already similar in their attitudes toward technology, and their learning style. This possibility implies the need for more research to be done in order to clarify the results.
For future research, this study should be replicated with a different population. Lukow's (2002) study showed no significant results with undergraduate students in recreation courses, and this study showed no significant results in regard to graduate students. Perhaps a study should be done using another graduate population with different characteristics.

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Using Metacognitive Strategies and Learning Styles to Create Self-Directed Learners

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Abstract

The purpose of this action research project was to help students become self-directed learners by determining what metacognitive strategies would be the most effective for a student's specific learning styles. Students were surveyed using the Perceptual Modality Preference Survey to determine their dominant learning styles. Students were then introduced to a new metacognitive strategy each week and asked to apply the strategy to their daily learning processes. Students were then asked to reflect on which metacognitive strategies best fit their learning styles. The results were then tallied to determine which strategies were preferred within the seven learning style groups.

Introduction

Each Friday, when the researcher was in fourth grade, the teacher reminded the class to "think about how we think," when studying for the spelling tests. She would explain that when she was in school, she would always sit at her desk in her room, quiet, to make sure that she was able to focus on her homework. She would rewrite her notes and try to link any new concepts that were taught to something she already knew in order to try to help her learn the new material that was being taught. As she would retell this story to us, the researcher would find himself daydreaming of his favorite cartoon, GI Joe. GI Joe and his band of warriors would fight the bad guys from COBRA. As usual, good would triumph over evil and the cartoon would end with a member of GI Joe's team giving a public service announcement (PSA) to a child that would expound on a life's lesson. The child in the PSA would respond to this newfound knowledge "Now I know!" and the GI Joe character would reply "And knowing is half the battle!" Little did the researcher know that that fourth grade teacher and GI Joe were trying to teach a similar lesson: that knowledge is power, especially when that knowledge is of how we learn best. That fourth grade teacher was trying to teach the students how to become a self-directed learner using metagcognition.

What is Self-Directed Learning?

As stated by Abdullah (2001), self-directed learners are "responsible owners and managers of their own learning process" (p. 1). Self-directed learning integrates self-management (management of the context, including social setting, resources, and actions) with self-monitoring (the process whereby learners monitor, evaluate, and regulate their cognitive learning strategies) (Bolhuis, 1996; Garrison, 1997).

Characteristics of a Self-Directed Learner

In order to help students understand how to become self-directed learners, teachers must first understand both the educational and motivational psychology behind self-directed learning. Even though a student can become a self-directed learner without understanding its psychological characteristics and the development of these traits, it is more likely to occur when teachers help foster them within the classroom (Biemiller & Meichenbaum, 1992).

According to Nelson & Conner (2008), teachers and administrators, along with parents and students, must have an understanding of the following characteristics of becoming a self-directed learner: student motivation, goal orientation, self-efficacy, and locus of control, self-regulation, and metacognition. These concepts provide a framework for helping students to truly gain an understanding of themselves as learners and how they can improve their self-awareness as a learner.

Student Motivation

Student motivation deals with a student's desire to actively participate in the learning process. But student motivation also focuses on the reasons that underlie a person's involvement or noninvolvement in academic activities. One of the main problems with determining a student's motivation level is that the sources of their motivation may differ.

A student who is intrinsically motivated undertakes an activity "for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of accomplishment it evokes" (Lepper, 1988, p. 292). In contrast, an extrinsically motivated student performs "in order to obtain some reward or avoid some punishment external to the activity itself," such as grades, stickers, or teacher approval (Lepper, 1988, p. 292). Although student motivation is inherently affected by the intrinsic motivation of the individual, there are many extrinsic factors that can positively influence the development of students' motivation, as well. Brophy (1986) states that "student motivation to learn is construed as a student tendency to find academic activities meaningful and worthwhile, and to try and get the intended academic benefits from them" (p. 8)

Goal Orientation

As defined by Caraway, Tucker, Reinke, and Hall (2003), it is the individual's ability to make plans and set goals, and works in combination with self-efficacy, to increase a student's motivation. One theory that focuses on the components of goal orientation is the target achievement goal theory, developed by Dr. Donna Woolard. The central focus of target achievement goal theory focuses on the method in which individuals determine their goals in achievement settings such as athletics or academics.

According to this theory, there are three factors that act together to determine a person's motivation: development of achievement goals, a person's self-perceived ability level, and the achievement behavior of the individual. In following this theory, individuals in an achievement setting are usually driven to follow one of two possible goals when determining whether or not they have been successful in goal setting. A person may have a task goal orientation, "where the focus is on improving performance relative to past performance, not on comparison with others. They have a stronger work ethic, are more persistent, and are better motivated because the factors they focus on are internal and more controllable" (Woolard, 2008, p. 1).

Others may have an outcome goal, or ego orientation, "…where they constantly compare themselves with others. Such factors are external and uncontrollable. They tend to give up more easily, and select tasks that are easier to perform" (Woolard, 2008, p. 1). Even though researchers continue to discuss whether the concept of task orientation or outcome goal orientation is more advantageous to an individual's ability to set and achieve goals, the majority of the literature related to goal orientation tends to support that task orientation is more favorable to positive behaviors in achievement settings.

Self-Efficacy

Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives (Bandura, 1994). Self-efficacy beliefs determine how people behave, think, feel, and motivate themselves. Self-efficacy, although somewhat similar to self-esteem, differs in one main concept. Self-efficacy is a personal belief of competency, rather than one's emotional reaction to an actual accomplishment (Nelson & Conner, 2008). It is also much more specific to an assignment (e.g. "I can determine the proper number of significant digits in a multiplication problem") instead of a general idea of proficiency (e.g. "I understand math"). A person with a strong feeling of efficacy strongly influences a person's achievement levels and personal comfort in many ways.

People with greater self-confidence in their capabilities approach complicated tasks as challenges to be mastered rather than as tasks to be avoided. Having a positive outlook and feeling of self-confidence helps to foster an intrinsic interest and deep fixation in activities. Individuals will set challenging goals for themselves and maintain a strong commitment to achieving them. When faced with new challenges, these individuals will intensify and sustain their efforts in the face of failure. They are also able to quickly recover their sense of efficacy after failures or setbacks. These individuals will attribute failure to inadequate effort or insufficient knowledge and skills, which can be acquired (Bandura, 1994). In contrast, people who doubt their capabilities tend to withdraw from difficult tasks which they view as personal challenges. These individuals, often times, have low aspirations and a limited dedication to the goals they choose to pursue. An individual with low efficacy, when faced with difficult tasks, often dwell on their personal deficiencies, on the obstacles they will encounter, and all kinds of adverse outcomes rather than concentrate on how to successfully achieve their goals. They usually give less than stellar level of effort and quickly give up in the face of adversity. They are slow to recover their sense of efficacy following failure or setbacks (Bandura, 1994).

The most effective way of creating a strong sense of efficacy is through mastery experiences. Successes build a robust belief in one's personal efficacy. A resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort. Some setbacks and difficulties in human pursuits serve a useful purpose in teaching that success usually requires sustained effort.

Locus of Control

Locus of control as defined by Miller, Fitch, and Marshall (2003) is "the tendency students have to ascribe achievements and failures to either internal factors that they control (effort, ability, motivation) or external factors that are beyond control (chance, luck, others' actions)" (p. 549). A person who is considered a self-directed learner would be described as having a greater internal locus of control then that of an external locus of control. In simple terms, the more internal the level of control, the greater the ability of the individual to deal with changes within their learning environment.

Self-Regulation

Zimmerman (2001) stated "self-regulated learning refers to learning that results from students' self-generated thoughts and behaviors that are systematically oriented toward the attainment of their learning goals" (p. 125). This technique is the method used by learners to help organize their thoughts and manage and adapt them into skills that are directed towards learning (Reid, 2008). Self-regulation is the practice of continuously monitoring one's progress toward a goal, examining outcomes, and redirecting unsuccessful efforts (Berk, 2003). In order for students to be self-regulated they need to be aware of their own thought process, and be motivated to actively participate in their own learning process (Zimmerman, 2001).

Metacognition

Metacognition can be loosely defined as "thinking about one's own thinking." More specifically, metacognition is "an appreciation of what one already knows, together with a correct apprehension of the learning task and what knowledge and skills it requires, combined with the ability to make correct inferences about how to apply one's strategic knowledge to a particular situation, and to do so efficiently and reliably" (Peirce, 2003, p. 2). Students who are able to identify suitable learning strategies in the proper situation are using metacognition. For example, a student may understand that he has difficulty in finding the connection between important concepts within a story. If he/she has been taught to use a graphic organizer, such as a concept map, to identify the main concepts and link them together using lines, similar to a spider web, then that student has used metacognition to complete the task (Nelson & Conner, 2008). In general, metacognition is the engine that drives self-directed learning.

One of the main struggles that students face in trying to develop an understanding of metacognition and ways to develop strategies that positively impact themselves is an overall lack of awareness to their own learning process. Students, even at a rudimentary level, have some basic understanding of their own knowledge and thinking. Flavell (1979) describes three basic types of awareness, related to metacognitive knowledge. The first is an awareness of knowledge, which is described as an understanding of what one does and does not know, and what one wants to know. Second, there is an awareness of thinking, which describes an understanding of cognitive tasks and the nature of what is required to complete them. Finally, there is an awareness of thinking strategies, which describes an understanding of approaches to directed learning.

Students can be encouraged to develop a sense of their own knowledge by asking questions such as, "What do I know?", "What don't I know?" and "What do I need to know?" These types of reflective questions can help students become more self-aware and help them to make real world connections to the information they are currently learning. In effective classrooms, teachers are responsible for helping students develop better metacognitive skills by incorporating active reflection throughout the learning process. Darling-Hammond, Austin, Cheung, and Martin (2008) listed the following examples of effective metacognitive strategies:

Predicting outcomes – Helps students to understand what kinds of information they might need to successfully solve a problem.

Evaluating work – Reviewing of work to determine where their strengths and weaknesses lie within their work.

Questioning by the teacher – The teacher asks students as they work. "What are you working on now?, Why are you working on it?, and "How does it help you?"

Self-assessing – Students reflect on their learning and determine how well they have learned something.
Self-questioning – Students use questions to check their own knowledge as they are learning.
Selecting strategies – Students decide which strategies are useful for a given task.
Using directed or selective thinking – Students choose consciously to follow a specific *line of thinking.*
Using discourse – Students discuss ideas with each other and their teacher.
Critiquing – Students provide feedback to other students about their work in a constructive way.
Revising – Students return their work after receiving feedback.

Metacognition affects a student's motivation to learn because it directly affects attribution and self-efficacy (Peirce, 2003). When students get results from assessments and grades on general assignments, especially when they receive unexpected results such as failure, students will try to mentally grasp and explain why these results occurred. When a student achieves good results, those with a strong sense of efficacy will attribute these results internally, to their own efforts and abilities. When a student achieves the same good results, but with a weaker sense of efficacy, will attribute there results to "being lucky" or "guessing correctly."

When students fail, some students will also focus on the same two internal reasons, while others will take more of a self-protective stance, choosing to focus on extrinsic factors, such as intrapersonal relationships, to allow the blame to fall elsewhere for their poor academic performance. A student with an extrinsic focus could make the following statement: "Well, Mr. Shannon only likes athletes, so I never get a good grade on his assignments." By modeling effective metacognitive strategies teachers allow their students to develop a deeper understanding of which strategies work best for their individual learning styles.

What are Learning Styles?

Learning styles refer to the concept that we, as individuals, process and perceive information in different ways. There are many different factors that can lead to the differences that arise within learning styles. These factors include, but are not limited to, personality, ability to process information, self-efficacy, sensory intake processes or some complex combination of these and other differences (Institute for Learning Styles Research, 2003). Using a variety of assessment tools, individuals can gauge their own interest levels for a set of criteria to help establish the methods in which they obtain much of their information about the world around them. One assessment tool that can be used in establishing a person's learning style is the Perceptual Modality Preference Survey (PMPS).

This survey focuses on seven perceptual sensory intake methods that help shape how, we as individuals, view the world around us. There are seven perceptual styles: print, aural, visual, interactive, haptic, kinesthetic, and olfactory (Institute for Learning Styles Research, 2003).

According to the Institute for Learning Styles Research (2003), print learning refers to seeing printed or written words. This type of learner often take notes, remember things easily that are read, recall information more readily after seeing or writing something, and often times, grasp important concepts on a first reading of material. Aural learning refers to listening. These learners excel within a lecture setting, are usually excellent listeners, can learn concepts by listening to a visual medium, such as pod casts or audio recordings, can reproduce symbols, letters or words by hearing them, and can repeat or fulfill verbal instructions with relative ease.

Interactive learning refers to verbalization (Institute for Learning Styles Research, 2003). These learners prefer group discussions, enjoy question and answer sessions, and like to use other people as a sounding board. Visual learning refers to seeing visual depictions (Institute for Learning Styles Research, 2003). These learners function well by seeing and by watching demonstrations, often have a vivid imagination, prefer to gain knowledge through visual media, and prefer visual stimuli such as pictures, slides and graphs. Haptic learning refers to the sense of touch or grasp (Institute for Learning Styles Research, 2003). These learners prefer a "hands on" approach to learning, tend to doodle on notebooks, and succeed with tasks requiring “hands on” manipulation. Kinesthetic learning refers to whole body movement (Institute for Learning Styles Research, 2003). These learners focus with direct involvement in things. They often fidget or find a reason to move, often find success in physical response activities, use movement to help concentrate, are usually poor listeners, and are not particularly attentive to visual or auditory presentations. Olfactory learning refers to sense of smell and taste (Institute for Learning Styles Research, 2003). These learners use smell to enhance learning, are frequently able to identify smells, and can associate a particular smell with specific past memories.

After researching the concepts of self-directed learning, learning styles, and metacognition, the goal for this research study was to determine the chemistry students’ individual learning styles using the PMPS. Next, a new metacognitive strategy was introduced to the students each week. Then the students reflected on each strategy to see if it positively affected their learning process, with the overall focus of helping the students to become more self-directed learners.

Methods

The study took place at a high school in a Midwestern Class C-1 school district. The district's enrollment is approximately 282 students in grades nine through twelve, with a 27% free/reduced lunch population and 14% of students receiving special education services. For this study, a total of 40 students participated in the action research project within the three chemistry classes. Of the 40 students, there were 20 females and 20 males. There were a total of four seniors, 28 juniors, eight sophomores, and no freshmen. Only one of the students participating in the study was on a modified special education plan and was able to receive services in the special needs room.

The teacher collected research data throughout the study in the form of anecdotal notes, teacher & student reflections, and classroom observations. The PMPS was administered at the beginning of the study, while teacher observations, reflections, and anecdotal notes occurred daily. In order to analyze the data, the PMPS results were analyzed and individual findings separated into the seven learning style groups and percentages were compiled. The researcher proceeded to determine which metacognitive strategies were preferred within each learning style group through the use of student comments and classroom observations. Comments were also sought from participants regarding the study.

During week one, the PMPS was administered online to the research group. The survey was analyzed by ranking each individual's learning styles, from highest to lowest. These individual results were then combined and ranked to determine the most prevalent learning styles within the group. In week two, students were asked to define what it means to be a self-directed learner. One student, a visual learner stated, "It is when a person takes ownership of what they want to learn." When the class was asked to expand upon this definition, another student replied "Ownership is when you give something value, that you need or want to keep". Other classes echoed the concept of ownership when asked about self-directed learning. An interactive learner stated, "It is when I decide to learn more about a topic then I am told to learn." Next, the students were given a more formal definition what is a self-directed learner taken from Abdullah (2001) that states that self-directed learners are "responsible owners and managers of their own learning process" (p. 1).

The students then discussed different factors that they felt affected a student, both positively and negatively, from becoming a self-directed learner. Most of the positive factors discussed were extrinsic factors, such as praise from parents, financial gains, and scholarships. Some of the negative factors listed were pressure to maintain grades, lack of knowledge on how to become better learners, and lack of motivation, which were predominantly intrinsic.

After week two, students were introduced to the overall concept of metacognition and its role in the development of self-directed learners. A new metacognitive strategy was introduced and modeled within a chemistry lesson during the week and students were then asked to incorporate the metacognitive strategy into their weekly study routine, when applicable. Students were then asked to use their laboratory journals to reflect on each strategy and whether it positively affected their learning process and their ability to become more of a self-directed learner. This routine was repeated throughout the ten-week study. The following schedule was used to introduce and implement a new metacognitive strategy each week, with the strategy listed below.

In week three, the strategy of predicting outcomes, which helps students to understand what kinds of information they might need to successfully solve a problem, was introduced. Students were given a teacher-created metacognitive form that outlined the three basic phases of metacognition: 1) developing a plan of action, 2) maintaining or monitoring the plan, and 3) evaluating the plan. Students were then given a "black box" lab activity in which an unknown object is placed within a container and students must use their senses, other than sight, to figure out what the object is. Students were given a series of questions, for each phase, to help them begin to think about the process of learning. For example, when students are in the first phase of developing a plan of action, one question that is listed asks, "What in my prior knowledge will help me with this particular task?"

In week four they were evaluating work (reviewing of work to determine where their strengths and weaknesses lie within their work). Students were given the concept "Density of Water" and asked to develop a lab procedure to accurately determine the density of water, which is a known constant of one. Students were then asked to reflect on the strengths and weaknesses of their lab procedure and to make suggestions on how they could improve their procedures.

Week five consisted of questioning by the teacher (The teacher asks students probing questions as they work). The teacher walked around the chemistry room and asked students questions such as, "Why did you choose the following measuring tool?" This was during a lab as students measured different items throughout the classroom. Students then had to explain their reasoning for choosing the measuring tool they used.

Week six involved self-assessments (Students reflect on their learning and determine how well they have learned something). Students were asked to reflect on how well prepared they were for an upcoming quiz on the different phases of matter and what concepts they still had not mastered.

During week seven, the students were self-questioning (Students use questions to check their own knowledge as they are learning). Students were asked to use their metacognitive forms again to analyze their use of a Venn diagram to compare and contrast Dalton's atomic theory to the modern atomic theory. Students were asked to reflect on the advantages and disadvantages of using this strategy and to give another example of a subject where a Venn diagram would be useful.

Week eight involved selecting strategies (Students decide which strategies are useful for a given task). Students were asked to develop a "visual project" to show the history of the atom and were given the freedom to use any visual medium they chose. They decided which strategy they wanted to use, e.g. PowerPoint™ presentations, poster board, etc., and what strategies they would use to put the project together. Week nine consisted of critiquing and revising (Students provide feedback to other students about their work in a constructive way and then students return their work after receiving feedback). Students were given cards that represented the original elements discovered by Mendeleev and asked to create their own periodic tables of elements using atomic mass as their guide. Students were then asked present their periodic tables to another lab group to be evaluated. The second group would offer feedback on a strength and weakness of group one's periodic table. The groups would then switch roles. The groups would then revise their periodic tables, if necessary, and turn in their final versions to the teacher to be formally evaluated.

Findings

After analyzing the data from student lab journals and metacognitive forms, four themes were apparent and they included the connection between learning styles and metacognitive strategies, self-assessment, and student motivation. First, the connections between a student's learning styles and preferred metacognitives strategies, as determined by students, was determined. Next, the concept of motivation, related to metacognition and the self-directed learner was addressed. Finally, the student's ability to self-regulate themselves to become self-directed learners was reviewed.

Connection Between Learning Styles and Metacognitive Strategies

The PMPS results were analyzed and there were 73% students who had kinesthetic as one of their top two ranked learning styles. This was followed by interactive with 45%, haptic with 38%, visual with 30%, print with 15% aural with 10%, and finally olfactory with no students represented. These learning styles were then used to help classify which metacognitive strategies were preferred by each learning style later in the study.

In this research study, the kinesthetic learners preferred selecting strategies, where they were given a direct involvement in selecting how they were able to present the material they learned. Conversely, interactive learners, which refers to verbalization, (Institute, 2003) preferred critiquing and revising, where they were allowed to share their opinions with others. Interactive learners were able to gain a greater depth of knowledge from the information that was shared within their study groups.

Similar to the kinesthetic learners, haptic learners, which refers to the sense of touch or grasp, (Institute, 2003) also preferred selecting strategies, which allowed them to have "hands-on" contact with the materials they were studying. In addition, visual learners, which refers to seeing visual depictions, preferred self-questioning and predicting outcomes, where they were able to use different forms of visual diagrams to help evaluate their learning process. While the ability to articulate is important for all learning styles, visual learners preferred being able to take the data they collected and use a variety of different visual methods, e.g. graphs, charts, to analyze it.

Students that were classified as print learners, which refers to seeing printed or written words (Institute, 2003) preferred self assessing, where they are able to reflect, usually in the form of a journal, to evaluate their learning process. Print learners often choose to be the recorder for a lab group and often shy away from situations where they would be expected to verbally discuss their findings.

Alternately, aural learners, which refers to listening, (Institute, 2003) preferred questioning by the teacher, where the student is able to gain perspective from another person. These students preferred to present information in the form of questions and often struggled to take visual notes or prompts and preferred to focus on what was being stated at the time.

Self-Assessment

Throughout the study, the researcher found that no matter the learning style a student might prefer, all of the students, whether consciously or unconsciously, were continuously evaluating their performance and their progress. Beyond comparing their results with other students, they wanted to be able to answer the question, "Am I actually getting this?" After analyzing the students' lab journals and metacognitive forms, the researcher was able to determine that the majority of students in the study preferred to use some metacognitive questioning to determine if they were "getting it", based on their previous learning experiences, before, during, and after the activity. For example, before students began a new assignment, they were given a series of questions to choose from to assess what information they already understood or additional information they still need to obtain to assist in their learning progression. Some of the questions posed before the activity were:
"What in my prior knowledge will help me with this particular task?"
"In what direction do I want my thinking to take me?"

"What should I do first?"
"Why am I reading this selection?"
"How much time do I have to complete the task?"

These questions were used to help the students begin the process of assessing what prior knowledge they may have on a particular subject and whether additional information must be obtained before starting the task. Students were then asked to use a second set of metacognitive questions to assess their learning during the activity. Some of the questions posed during the activity were:
"How am I doing?"
"How should I proceed?"
"Am I on the right track?"
"What information is important to remember?"
"Should I move in a different direction?"
"What do I need to do if I do not understand?"

Finally, students were asked to use a closing set of metacognitive questions to assess their learning after the activity. Some of the questions posed after the activity were:
"How well did I do?"
"What could I have done differently?"
"Did my particular course of thinking produce more or less than I expected?"
"How might I apply this line of thinking to other problems?"
"Do I need to go back through this task to fill in any "blanks" in my understanding?"
By using these metacognitive questions, students were able to begin the process of being able to "self-assess" what they were learning and allowing themselves the opportunity to gain a greater grasp of the material presented.

Student Motivation

One of the main focuses of the study was to help the students within the research study to understand where their motivation for educational success lies. Too often, a student's focus on academic success is often times extrinsic. Although parents and teachers can offer many beneficial, extrinsic, motivational factors, but one important factor is the context and manner in which the motivation is given or received. As previously stated, the concepts of motivation and self-efficacy are interrelated. Primarily, an underlying self-efficacy must always be present because if a child believes she can do well, then she will (Pintrich, 2004).

If a student believes that a specific academic goal is unattainable, then a student will lack the self-motivation to attempt to achieve that goal. Extrinsic motivation causes students to perceive more goals as unattainable, whereas and intrinsically motivated student will see very few goals as unattainable because that student believes that anything is possible with effort. Throughout the study, the focus for students was to provide encouragement as they were attempting to use their new metacognitive strategies. By encouraging the students to use new strategies, the focus was to assist students in their natural curiosity to discover more about how they learn best. Throughout school, in general, curiosity can be one of the strongest motivators with regards to motivation. This need will intrinsically motivate students to discover and understand new concepts that otherwise would remain untouched. This curiosity was evident throughout the study, as students began to use the metacognitive questions to help them determine if learning was occurring throughout each activity.

Conclusions

Based on these findings, teaching students metacognitive strategies is a valuable skill that helps students become more self-directed learners. Before the study, the majority of the students did not give any thought to "how they learn" and what type of learning style they have. But now, these students are interested in developing a "study skills" course that would be mandatory for all incoming freshmen. Students were interested in trying the learning styles survey to help them "think about how they think". That fourth grade teacher and GI Joe had it right all along, "Knowing is half the battle", especially when it comes to becoming a self-directed learner.

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Learning Styles: How Do They Fluctuate?

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Abstract

In general, the theory of learning styles states that people have different approaches to learning and studying (Dunn & Dunn, 1978; Dunn & Dunn, 1987; Felder & Brent, 2005; Felder & Henriques, 1995; Hall, 2005; Heiman, 2006; Manochehri & Jon, 2006; Mupinga, Nora, & Yaw, 2006; Price, 2005; Sheridan & Steele-Dadzie, 2005; Silverman, 2006; Ware, & O'Donoughue, 2005.). Given a specific instruction method or environment, some people will learn more effectively than others due to their individual learning style. However, this may not be the case throughout a course or a specific lesson. Learning styles actually fluctuate within subject or lesson. The research presented here discusses learning styles and how learning styles can vary from lesson to lesson within a specific course as observed using an advanced learning technology. The research focuses on students in computer science and engineering.

Introduction

The purpose of this research was to gain insight and hopefully improve teaching methods to facilitate student achievement and retention in the disciplines of Science, Technology, Engineering, and Mathematics. The findings from this research provide insight as to why certain students may not learn specific topics within a course and find other lessons within the same course easy to learn. Sometimes, students do not gain a deeper understanding because of the instructional methods employed by the professor, which may not be conducive for his or her learning style. If an understanding of the concept is not acquired, some students resort to rote memory. Biggs (1996) however argues that memorizing may result in deep learning albeit using an approach regarded as outdated by current Western pedagogy. The overall aim of this research project was to identify or confirm how learning styles fluctuate within a lesson.

Review of Literature

There exist very few studies of learning styles of computer science and engineering students. Learning styles affect the way students acquire and process information. Felder and Silverman (1988) reported students preferentially take in and process information in different ways: by seeing and hearing, reflecting and acting, reasoning logically and intuitively, analyzing and visualization, steadily and in fits and starts. According to Tripp & Moore (2007), "students tend to focus on facts, data, and algorithms. Some respond strongly to visual forms of information and many others prefer to learn actively and individually" (p. 24).

"Teaching methods also vary. Some instructors lecture, others demonstrate or lead students to self-discovery; some focus on principles and others on applications; some emphasize memory and others understanding" (Felder & Silverman, 1988, p. 1). If the issue of learning styles is addressed within the Science, Technology, Engineering, and Mathematics (STEM) disciplines, there is a possibility that some of the concerns associated with acquisition and retention of students may be resolved (Gilbert, 2006; Jackson, 2004; National Academies, 2005). Students often become uninterested and restless during class when there is no correlation between the way students learn and the way instructors teach. Students also become:

> bored and inattentive in class, do poorly on tests, get discouraged about the courses, the curriculum, and themselves, and in some cases change to other curricula or drop out of school. Professors, confronted by low test grades, unresponsive or hostile classes, poor attendance and dropouts, know something is not working. They may become overly critical of their students (making things even worse) or begin to wonder if they are in the right profession. Most seriously, society loses potentially excellent professionals. To overcome these problems, professors should strive for a balance of instructional methods (as opposed to trying to teach each student exclusively according to his or her preferences.) If the balance is achieved, all students will be taught partly in a manner they prefer, which leads to an increased comfort level and willingness to learn, and partly in a less preferred manner, which provides practice and feedback in ways of thinking and solving problems which they may not initially be comfortable with but which they will have to use to be fully effective professionals. (Felder & Spurlin, 2005, p. 1)

If issues associated with teaching pedagogy of engineering students continue to go unaddressed, the attrition rate in engineering will continue to spiral downward, (Gilbert, 2006; Stice, 1987). Consequently, it is imperative that we explore how learning styles of engineering students fluctuate within the context of a lesson.

Learning Styles

Dunn (1978) indicated that learning styles are approaches to learning and studying. Keefe (1982) defined learning styles as characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with or respond to the learning environment. Dunn and Perrin (1994) described learning styles as "the way in which each learner begins to concentrate on, process, and retain new and difficult information. That interaction occurs differently for each individual" (p. 2). Gilbert and Han (1999) and Gilbert (2000) confirmed that learning preferences facilitate the way individuals learn when the learning environment considers the various learning styles of students, thereby impacting the comprehension of materials presented. Felder and Spurlin (1995) describes learning styles as "characteristic strengths and preferences in the ways they take in and process information" (p. 1). Felder et al. (2002) indicated that learning styles are often reflected in "different academic strengths, weaknesses, skills, and interests" (p. 3). Learning styles are often influenced by heredity, upbringing, and current environmental demands. Individuals have a tendency to both perceive and process information differently. According to Funderstanding (2008), some learners use:

1. Concrete and abstract perceivers—Concrete perceivers absorb information through direct experience, by doing, acting, sensing, and feeling. Abstract perceivers, however, take in information through analysis, observation, and thinking.
2. Active and reflective processors—Active processors make sense of an experience by immediately using the new information. Reflective processors make sense of an experience by reflecting on and thinking about it.

Tripp and Moore (2007) reported:

> Dunn and Dunn (1992) suggest that research on learning styles provides direction for either how to teach individuals through their styles, patterns or how to teach them by capitalizing on their personal strengths. Learning style can also be defined as the way in which each learner begins to concentrate on, process, and retain new and difficult information. Identifying learning styles and adapting lessons can motivate, encourage students to succeed, and eliminate unfair labeling. Different individuals perceive and process experiences in different preferred ways (Brokaw & Merz, 2000; Dunn & Dunn, 1989; Dunn, Griggs, Olson, Beasley, & Gorman, 1995; Felder, 1993; McCarthy, 1981). Students' unique learning styles are comprised of these preferences. McCarthy (1981) identified three basic types of learners; visual, auditory, and kinesthetic. Visual learners process information through sight (pictures, models, diagrams, demonstration, and other visual aids). Auditory learners use hearing as their main source of information. Their preference is lecture, discussions, and listening to others. Kinesthetic learners prefer hands on approaches to acquire knowledge. This type of learner likes to explore the physical world by touching and movement (McCarthy, 1981). (p. 25)

According Felder et al. (2002), "people have different learning styles that are reflected in different academic strengths, weaknesses, skills, and interests. Understanding learning style differences is thus an important step in designing balanced instruction that is effective for all students" (p. 3). There are several models of learning styles that are currently being used to assess how students learn. Using these assessments will facilitate in understanding how learning styles fluctuate within a specific context.

Models of Learning Styles

"A learning style model classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information," (Felder & Silverman, 1988, p. 3). "Identifying each student's learning style is an extremely difficult task. Furthermore, it becomes an impossible task to accommodate everyone's learning style in a classroom or tutoring environment" (Gilbert & Han, 1999, p. 4). Learning styles influences the way in which students learn. When one understands his or her learning styles, he or she can make the appropriate modifications to increase academic achievement.

There are various tools available to assess learning styles. They are over 80 models today that are used to ascertain learning styles. Some of the most commonly used assessments are: 1) Myers-Briggs Type Indicator (MBTI); 2) Howard Gardner's Multiple Intelligence Model; 3) the DISC assessment; 4) Learning Styles Inventory; and 5) Index of Learning Styles.

The *Myers-Briggs Type Indicator* is a personality assessment designed to identify certain psychological differences according to the typological theories of Carl Gustav Jung (Wikipedia Myers Brigss Type Indicator, 2008). The *Multiple Intelligence Model* basically indicates that paper and pencil does not show the full range of intelligence of an individual. Gardner defines intelligence as the capacity to solve problems or to fashion products that are valued in one or more cultural settings. Multiple Intelligence Model consists of seven dimensions of intelligence: "1) Visual/Spatial; 2) Musical Intelligence; 3) Verbal/Linguistic Intelligence; 4) Logical/Mathematical Intelligence; 5) Interpersonal Intelligence; 6) Intrapersonal Intelligence; and 7) Bodily/Kinesthetic Intelligence" (Wikipedia Howard Gardner, 2008, p. 1).

The *DISC assessment* is an inventory model of learning styles which is composed of four quadrants that is classified by behavior. DISC assesses a person's preferences in word associations. DISC is an acronym for Dominance, Influence, Steadiness, and Conscientiousness (Wikipedia DISC, 2008, p. 1). *Learning Styles Inventory* is an assessment that is used to determine the learning styles of students, colleagues, and yourself. "The *Index of Learning Styles* is a self-scoring instrument that assesses preferences over four scales: 1) the Sensing/Intuiting, 2) Visual/Verbal, 3) Active Reflective, and 4) Sequential/Global dimensions" (Felder & Silverman, 2002, p. 2A).

Learning Styles in STEM

Colleges and universities today realize that students learn in different ways. "Thus, they need to provide multiple strategies for learning," and also recognize that depending upon the lesson taught that learning styles can and will vary, (Dunn et al., 1994, p. 9). It is imperative that we show that one learning style is not the only learning style that is dominant with respect to an individual or discipline. However, one person can have several learning styles relative to a specific course or subject. For example, in a mathematics course, when solving equations, student can learn visually. This means that solving problems on the white board, watching a video demonstration of solving mathematical equations, and providing very specific examples on the overhead assists a visual learner in understanding the objective taught.

On the other hand, when the objectives change, the learning style may also change. For example, if the teacher's objective is graphing equations they are written in slope intercept form. With this particular lesson, the student may not be a visual learner, but kinesthetic. The student needs a lot of hands-on practice to obtain a clearer understanding of how to graph linear equations in slope intercept form. Given these examples, professors may address the different learning styles within their courses by including within their syllabus an outline that addresses the different learning styles with respect to the objectives being taught. This could facilitate any concerns as it relates to how students learn, the way professors teach, and student achievement.

Mismatches sometimes occur between the way that a professor teaches and the actual way that a student learns. Tripp and Moore (2007) indicated that typically in engineering classes students are viewed as passive and not seen as active or reflective. Felder and Silverman (1988) suggest to improve test scores, reduce hostile classes, poor attendance and drop outs, it is necessary that a teaching style that is both effective for students and comfortable for the professor is implemented.

The Felder-Silverman Learning Style Model was used effectively in engineering education and the sciences (Felder & Spurlin, 2005). Felder and Silverman's model is based on strategies that present information that appeals to a range of learning styles (Felder & Silverman, 1988). These strategies are:

1. Teach theoretical material by first presenting phenomena and problems that relate to the theory;
2. Balance conceptual information with concrete information;
3. Make extensive use of sketches, plots, schematics, vector diagrams, computer graphics, and physical demonstration in addition to oral and written explanations and derivations in lectures and readings;
4. Illustrate an abstract concept or problem solving algorithm, use at least one numerical example to supplement the usual algebraic example;
5. Use physical analogies and demonstrations to illustrate the magnitudes of calculated quantities;
6. Provide class time for students to think about the material being presented and for active student participation;
7. Occasionally give some experimental observations before presenting the general principle, and have the students see how far they can get toward inferring the latter. (p. 26)

Method

In this study, data from a web based instructional system named Arthur (Gilbert & Han, 2002) was used to determine how the learning styles of students fluctuated within the context of a lesson. Arthur is a web-based instructional tool that uses adaptive instruction to accommodate learning styles (Gilbert, 2000; Gilbert & Han, 1999; Gilbert & Han, 2002). Adaptive instruction refers to the fact that Arthur is composed of multiple explanations for the same lesson or concept. Each explanation uses a different instruction style to deliver the same content. More information regarding the instructional methods will be discussed later. After receiving instruction, the student is required to take an assessment or quiz. Arthur requires each learner to perform at a mastery level (Bloom, 1976; Woolfolk, 1998) on the quiz that immediately follows each lesson or concept, which is the threshold required to advance from lesson to lesson or concept to concept. If a learner does not perform at a masterly level, they are forced to repeat the same lesson or concept; however, the instructional method is changed using adaptive instruction (Gilbert, 2000; Gilbert & Han, 1999; Gilbert & Han, 2002).

There were 89 undergraduate students that participated in the experiment. All of the students were enrolled in a C++ programming course at the time of the experiment. C++ is a popular software programming language used in computer science and engineering curriculums, (Gilbert, 1999). The students all had prior programming experience with C++ covering topics such as arrays, loops, selection and functions. None of the students had prior knowledge of pointers in any other language. Pointers are often seen as a very difficult subject for students learn in programming classes. The students were accustomed to using the Web within the classroom environment. Participation was strictly voluntary.

The students were given Web access to Arthur with a login and password via their Web browser. The students were required to have a C++ compiler to compile and run downloaded C++ source code examples. With the hardware and software requirements satisfied, the students were able to use Arthur, while valuable data statistics were collected in the background.

Five lesson modules and assessments were created to assess students' knowledge of the C++ programming language over the following concepts:

1. Pointers (Introduction)
2. Pointers (Constants, Parameters)
3. Pointers and Arrays
4. Pointers and Strings
5. Pointers and Strings (Array of pointers, string library)

Each lesson was provided through Arthur using seven different instructional methods. The instructional methods were:

1. Text with explanations preceding examples - This instruction style used text and C++ source code samples to explain concepts with explanations of the concepts preceding the examples.
2. Text with examples preceding explanations - This instruction style used text and C++ source code samples to explain concepts with examples of the concepts preceding the explanations.
3. Audio with explanations preceding examples - This instruction style used text, C++ source code samples and streaming audio to explain concepts with explanations of the concepts preceding the examples. The audio provided verbal explanations of the source code illustrations.
4. Audio with examples preceding explanations - This instruction style used text, C++ source code samples and streaming audio to explain concepts with examples of the concepts preceding the explanations. The audio provided verbal explanations of the source code illustrations.
5. Visual with explanations preceding examples - This instruction style used text, C++ source code samples, and pictorial images of pointer concepts with explanations of the concepts preceding the examples.
6. Visual with examples preceding explanations - This instruction style used text, C++ source code samples and pictorial images of pointer concepts with examples of the concepts preceding the explanations.
7. Hands On with examples preceding explanations - This instruction style used text, C++ source code samples, streaming audio and pictorial images of pointer concepts with examples of the concepts preceding the explanations. This instruction style also used interactive source code puzzles. The puzzles provided partially completed programs where the learner filled in the blanks.

These instructional methods were provided to the learners to choose at their own free will. The learners could change instructional methods after taking a quiz only if their score was below mastery level, which was 80%. This gave the learners the power to select their instructional method when corrective instruction was necessary.

Findings

Table 1 describes the concepts and the average number of attempts to complete each concept regarding pointers in the C++ programming language. For example, the "Introduction to Pointers" concept under Arthur took learners an average of 2.47 attempts to pass the concept quiz. According to learning styles theory, one would imagine once the student identifies an instructional method that works for him/her, i.e. they passed the first concept, they should be able to stick with that instructional method and use it throughout the remaining concepts with the same success; however, our findings show otherwise. After the first concept, Pointers (Introduction), the students on average required 1.72 attempts to pass the second concept, 1.25, 1.28 and 1.80 for the remaining concepts, respectively.

Table 1
Average Number of Attempts to Pass Each Concept

Concept	Average Number of Attempts per Concept
Pointers (Introduction)	2.47
Pointers (Constant, Parameters)	1.72
Pointers and Arrays	1.25
Pointers and Strings	1.48
Pointers and Strings (Array of Pointers, String Library)	1.80

These data illustrate the use of repetition before passing any given lesson. Students repeated each lesson at least once before passing the end of concept/lesson quiz. Furthermore, within those repetitions, on average 2.25 different instruction methods were used. In other words, students preferred to have lessons explained using a different instruction method when they were required to repeat a concept/lesson. Recall, that the students were given the freedom to choose instructional methods.

Table 2 demonstrates the average number of attempts per instructional method across all the concepts. Notice that Hands-On Mode with Examples 1st performed the worst with an average of 2.86 attempts and Text Mode with Examples 1st performed the best with an average of 1.42 attempts. In general, the Example 1st methods outperformed the Explanations 1st methods. There was a 0.99 point difference between the Visual Mode with Explanation 1st method (2.78) and Audio Mode with Explanation 1st method (1.79), which is the best for Explanations 1st and worst for Examples 1st, respectively. This gap demonstrates a clear separation between Explanations 1st and Examples 1st. Within the classroom, it is most common for faculty to teach C++ or any other programming language using an Explanations 1st approach vs. an Examples 1st approach.

Table 2
Average Number of Attempts to Pass Each Concept

Instructional Method	Average Number of Attempts per Method
Hands-On Mode with Examples 1st	2.86
Text Mode with Explanations 1st	2.86
Visual Mode with Explanation 1st	2.78
Audio Mode with Explanation 1st	1.79
Audio Mode with Example 1st	1.50
Visual Mode with Example 1st	1.46
Text Mode with Examples 1st	1.42

Conclusion

In this experiment, when a student was not able to obtain the mastery level required to advance onto the next logical concept/lesson, the student was required to repeat the current concept and the student was allowed to choose the instructional method. Our findings indicated that the learning styles of students may fluctuate within the context of a course from concept to concept, or lesson to lesson. These findings suggest that students needed repetitive instruction while varying the instructional method before mastering each concept. Learning styles theory indicates that people have different approaches to learning and studying.

It is commonly thought that once a student's learning style has been identified, the instructor can provide instruction that corresponds to the student's learning style (Carver, Howard, & Lane, 1999; Laroussi & Ben Ahmed, 1998; Wallace & Mutooni, 1997). According to the findings here, identifying a student's learning style and teaching to that learning style may not be enough because the student's learning style may fluctuate across concepts/lessons. The results from this study also show that instructors should strongly consider using an Examples 1st approach vs. an Explanations 1st approach when teaching Pointer concepts in C++.

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The Impact of Learning Styles on High Stakes Testing: Perspectives from Mississippi Delta Area Teachers

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Abstract

The purpose of this study was to explore the extent to which teachers in the Mississippi Delta were addressing learning styles at the middle school level. The evaluation addressed methods used to identify learning styles, the impact of learning styles on academic performance, the extent to which learning styles were addressed in school improvement and lesson plans, and instructional delivery and assessment. Data was obtained from questionnaires, classroom observations, review of school improvement and lesson plans, interviews and the Mississippi Curriculum Test. The evaluation found all surveyed teachers (1) addressing learning styles to some extent, (2) reporting increasing academic performance, and (3) making a special effort to develop corresponding activities to enhance learning.

This material is based upon work supported by the Mississippi State Department of Education (MDE) under Grant. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author and do not necessarily reflect the view of MDE.

Introduction

At one time or another, all instructional methods have been criticized, and as professionals we are called upon time after time to defend our teaching methodologies (Dunn & Dunn, 1978). This call may be because it has become obvious that many instructional methods that are highly effective for some students are not appropriate for others. Upon entering our classrooms, in many ways, the students appear to be very much alike; their ages are nearly the same, they have similar interests, and they study common subjects. Rather, a closer look reveals many diverse individuals (Snowman & Biehler, 2003), not only in terms of ethnicity, gender, age, nationality, and cultural background, but also and most important, how each individual learns.

Learning styles are defined by Snow, Corno and Jackson (1996) as students' approaches to learning, problem solving, and processing information. The challenge of today's schools is to assess each child's learning style characteristics and to provide teaching interventions that are compatible with those traits (Griggs, 1991). Diagnosing and interpreting learning styles provide important data as to how individuals perceive, interact with, and respond to the learning environment (Griggs, 1991). Moreover, according to Reiff (1992), diagnosis can provide teachers with theory and knowledge upon which to make more informed decisions about instructional methods. As we focus on our own style of learning, it makes us aware of the interventions that we tend to favor over others, thus accommodating some styles that are similar to our own and possibly, without being aware, alienating others who have different learning styles (Griggs, 1991). The literature seems to suggest that diagnosing students learning styles can be an easy and effective process because students can identify their own learning styles and score higher on tests when they are complimented with a teaching style that matches their learning style. These findings may serve to be important in the mist of high stakes testing.

According to Eggen and Kauchak (2004), the concept of learning styles has at least three implications for teachers. First, learning styles can remind educators that they need to vary instructions (Shuell, 1996). Activities such as individual projects, small-group discussions, cooperative learning, and learning centers provide flexibility in meeting individual needs. Second, the concept of learning style should remind educators of the need to help students become more aware of the ways they most effectively learn (Eggen & Kauchak, 2004). Sternberg (1998) linked learner self-awareness to intelligent behavior. Third, the concept of learning style should remind educators that students are different and that they should increase their sensitivity to those differences. With increased sensitivity, educators are more likely to respond to students as individuals (Eggen & Kauchak, 2004).

Many types of learning styles have been introduced; however, Kolb (1984) identified three of the most popular types of learners and described some ways in which they learn. First, the visual learner within Kolb's paradigm prefers to learn through written language, such as reading and writing tasks. This learner usually remembers what has been written down even if it has only been read once. Information typically does not exist for a visual learner unless the information is written down. Visual learners make up about 65% of the population (Mind Tools, 2000). Next, the auditory learner is more at ease with the spoken word or language. They usually talk to themselves and read information out loud. This type of learner may listen to a lecture and write down notes afterward. Written information has no meaning to these individuals unless they have heard it. Auditory learners make up about 30% of the population (Mind Tools, 2000). Finally, the kinesthetic learner effectively learns through touch, movement and space while their skills are learned through imitation and practice. This type of learner tends to lose concentration when little or no movement exists and may appear to be slow, especially when information is not presented in a style that compliments their learning style. Kinesthetic learners make up about 5% of the population (Mind Tools, 2000).

The successful education of students is currently under a microscope. As a result, low academic achievement and low test scores are blamed on the school, teachers, and the instructional programs or methods being used. Schroeder (1996) suggests that educators expound on the amount of learning activities open to them which may greatly increase their satisfaction and students' learning. Schroeder believes that engaging in such a process that clearly indicates that there are many paths to excellence can help meet the needs of students. In addition, this process may serve to take some of the burden off schools and their faculty.

The purpose of this evaluation was to explore the extent to which teachers are addressing learning styles at the middle school level for students enrolled in mathematic courses. This evaluation sought to discover if teachers' understanding of learning styles are fundamental to their individual approaches to teaching and does the use of learning styles have a positive impact on student's test performance, therefore, allowing educational professionals to be responsive to a more diverse student body. The results will add to the literature concerning the importance of using learning styles to achieve academic success of students in Mississippi. This evaluation addressed the following six questions:

1. To what extent are school improvement plans addressing learning styles of middle school math students?
2. How do teachers use learning styles to plan instruction?
3. How do teachers use learning styles to deliver instruction?
4. How do teachers use learning styles to assess students' achievement?
5. What methods are teachers using to identify learning styles?
6. What impact does the use of learning styles have on mathematics performance?

Methods

Participants were selected from middle schools in Mississippi. Participants consisted of middle school mathematics teachers from Mississippi Delta Area schools. One hundred seventy-one teachers were selected from a list of Mississippi Schools provided by the Mississippi Department of Education. The schools are classified as either rural, outside a metropolitan statistical area, inside metropolitan statistical area, small town, large town, urban fringe of large city, urban fringe of mid-size city.

Instrumentation

A mixed methods evaluation was designed to answer the evaluation questions. Mathematics teachers in the targeted middle schools were asked to complete a questionnaire, agree to an interview and permit a classroom observation to determine how learning styles are being addressed. A closed-form questionnaire was developed specifically for this evaluation. The questionnaire was designed to measure the opinions of middle school mathematics teachers regarding the use of learning styles in planning and delivering instruction, and assessing student performance. The questionnaire consisted of 15 questions/statements and consumed an estimated 15 minutes of the teacher's time to complete.

Participants responded to questions pertaining to years of experience, certification, grade level taught, definition of learning styles, extent to which learning styles are addressed in school improvement plans, extent to which learning styles are addressed in lesson plans, extent to which learning styles are addressed when delivering instructions, extent to which learning styles are addressed when assessing mathematics achievement, methods used to identify learning styles, impact of learning styles on student's mathematics performance, training in the use of learning styles, rationale for addressing learning styles, addressing learning styles if more training was provided, and a classroom observation. Responses from middle school mathematics teachers provided information from one of the most important sources related to this issue. Fifty-seven out of one hundred seventy-one questionnaires were returned.

In collecting the data, all participants met the only requirements needed to participate in the study "they were middle school mathematics teachers within schools located in the Mississippi Delta." Participants were delivered questionnaires through regular mail. Cover letters accompanied the questionnaires. Upon completion of the questionnaires, teachers were asked to return their responses in the self-addressed envelopes provided. In an attempt to increase the response rate, a follow-up was conducted. Required data were collected from questions answered on the closed-form questionnaires. The closed-form questionnaire was used for the purpose of ensuring opinionated responses. On using a closed-form questionnaire Borg and Gall (1983) states "the questions permit only certain responses so that qualification and analysis of the results may be carried out efficiently" (p. 419). Returned questionnaires were reviewed and analyzed. Charts, tables and percentages were used in describing the data.

Classroom Observation

Classroom observations were conducted in order to explain how middle school mathematics teachers were addressing learning styles to a high extent. From the returned questionnaires, a three-step selection process was used to select the schools to be visited for conducting interviews, classroom observations, and reviewing relevant documents (i.e., lesson plans). First, questionnaires were assigned case numbers for identification purpose. Cases were eliminated from the observation if the total score of survey questions 7, 8, and 9 was less than 9. Of the 57 useable questionnaires, 13 teachers had a total score of 9 on the three questions. Of the 13, only 6 indicated, on the questionnaire, that the evaluator could conduct a classroom observation.

Using the Mississippi Curriculum Test (MCT) 2003-2004, test data were collected on the 13 cases and a comparison was made on the combined proficient and advanced scores. The final selection of schools included the top four cases having the highest combined proficient and advanced student scores in the area of math and agreeing to the classroom observation (see Table 1).

Table 1
Proficiency Level Distribution 2003-2004

CASE #	**Percentage of Students Scoring Minimal, Basic, Proficient or Advanced in the Areas of Math on the Mississippi Curriculum Test (2003-2004)**						
	SUBJECT GRADE	NUM	MEAN SS	<---PROFICIENCY LEVEL DISTRIBUTION--> MINIMAL	BASIC	PROFICIENT	ADVANCED
19	GRADE 6	134	560.3	17.9%	11.2%	33.6%	37.3%
	GRADE 7	145	569.3	26.9%	14.5%	33.1%	25.5%
44	GRADE 6	55	553.4	14.5%	23.6%	40.0%	21.8%
	GRADE 7	106	542.3	53.8%	24.5%	17.0%	4.7%
	GRADE 8	94	590.9	18.1%	18.1%	43.6%	20.2%
56	GRADE 6	19	561.5	0.0%	21.1%	57.9%	21.1%
	GRADE 7	21	560.4	33.3%	23.8%	14.3%	28.6%
	GRADE 8	25	628.8	0.0%	4.0%	40.0%	56.0%
57	GRADE 6	134	560.3	17.9%	11.2%	33.6%	37.3%
	GRADE 7	145	569.3	26.9%	14.5%	33.1%	25.5%
	GRADE 8	142	608.3	5.6%	12.0%	48.6%	33.8%

Personal interviews were conducted in an attempt to provide additional evidence. Teachers addressed interview questions based on trend data analysis of MCT scores from the years 2001-2004 (see Tables 1, 2, and 3).

Table 2
Proficiency Level Distribution 2002-2003

CASE #	**Percentage of Students Scoring Minimal, Basic, Proficient or Advanced in the Areas of Math on the Mississippi Curriculum Test (2002-2003)**						
	SUBJECT GRADE	NUM	MEAN SS	<---PROFICIENCY LEVEL DISTRIBUTION--> MINIMAL	BASIC	PROFICIENT	ADVANCED
19	MATHEMATICS						
	GRADE 6	134	554.9	17.9%	20.9%	33.6%	27.6%
	GRADE 7	157	563.8	29.9%	15.3%	38.9%	15.9%
44	GRADE 6	81	528.1	32.1%	32.1%	30.9%	4.9%
	GRADE 7	98	551.9	41.8%	22.4%	26.5%	9.2%
	GRADE 8	81	584.1	24.7%	24.7%	37.0%	13.6%
56	GRADE 6	19	561.4	15.8%	5.3%	57.9%	21.1%
	GRADE 7	24	590.3	12.5%	12.5%	37.5%	37.5%
	GRADE 8	22	565.8	40.9%	22.7%	31.8%	4.5%
57	GRADE 6	134	554.9	17.9%	20.9%	33.6%	27.6%
	GRADE 7	157	563.8	29.9%	15.3%	38.9%	15.9%
	GRADE 8	141	595.4	14.2%	23.4%	34.0%	28.4%

Table 3

Proficiency Level Distribution 2001-2002

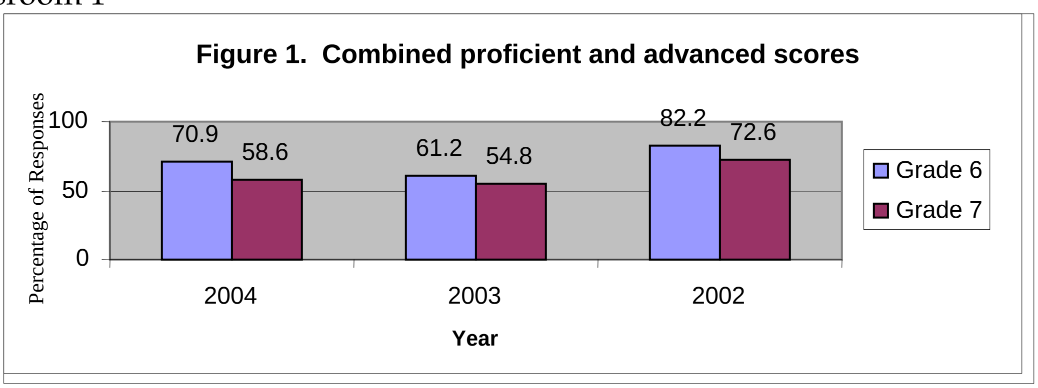
CASE #	Percentage of Students Scoring Minimal, Basic, Proficient or Advanced in the Areas of Math on the Mississippi Curriculum Test (2001-2002)						
	SUBJECT GRADE	NUM	MEAN SS	<---PROFICIENCY LEVEL DISTRIBUTION--> MINIMAL	BASIC	PROFICIENT	ADVANCED
19	MATHEMATICS						
	GRADE 6	175	570.1	10.9%	6.9%	29.1%	53.1%
	GRADE 7	157	580.4	12.7%	14.6%	51.6%	21.0%
44	GRADE 6	66	519.0	43.9%	24.2%	25.8%	6.1%
	GRADE 7	84	545.8	51.2%	25.0%	17.9%	6.0%
	GRADE 8	95	563.4	46.3%	21.1%	24.2%	8.4%
56	GRADE 6	27	553.2	14.8%	22.2%	33.3%	29.6%
	GRADE 7	24	543.4	58.3%	16.7%	20.8%	4.2%
	GRADE 8	21	577.0	28.6%	23.8%	42.9%	4.8%

Teachers were asked to look at the charts/figures relating to their school and provide answers to the following questions from the questionnaire:

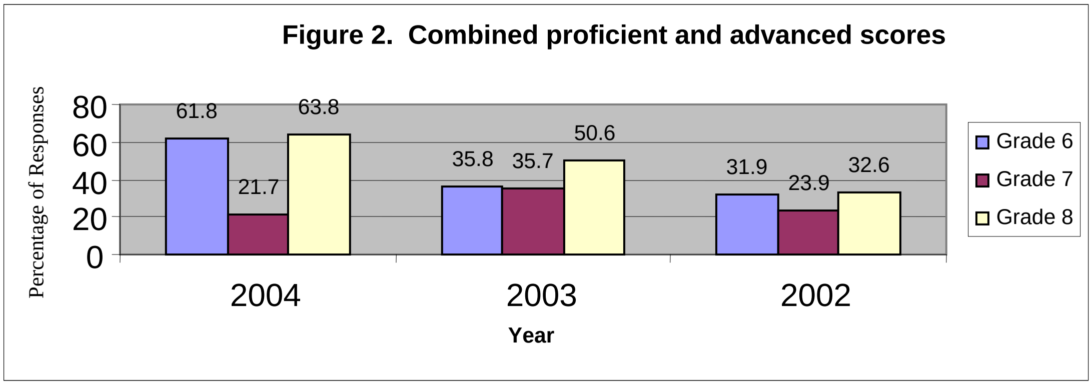
7. Were you teaching at this school during the 2001-2004 school years?
8. How were you addressing learning styles?
9. How do you explain the increase/decrease in test scores during these years?

Chart/figures depict combined proficient and advanced scores for the 2001-2004 school years for each school observed (see Figures 1, 2, 3 and 4).

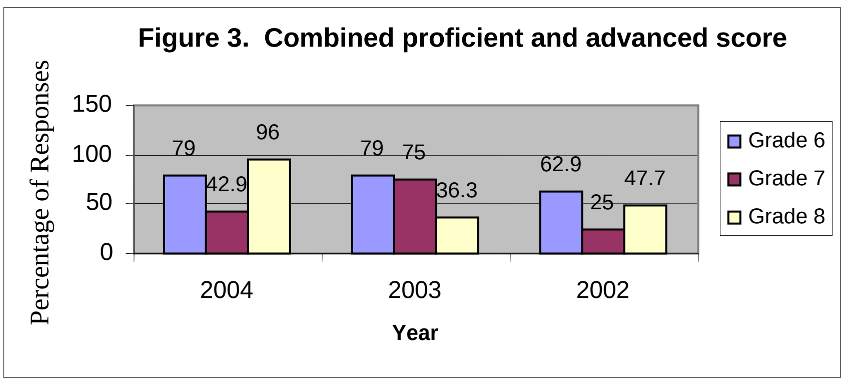
Classroom 1



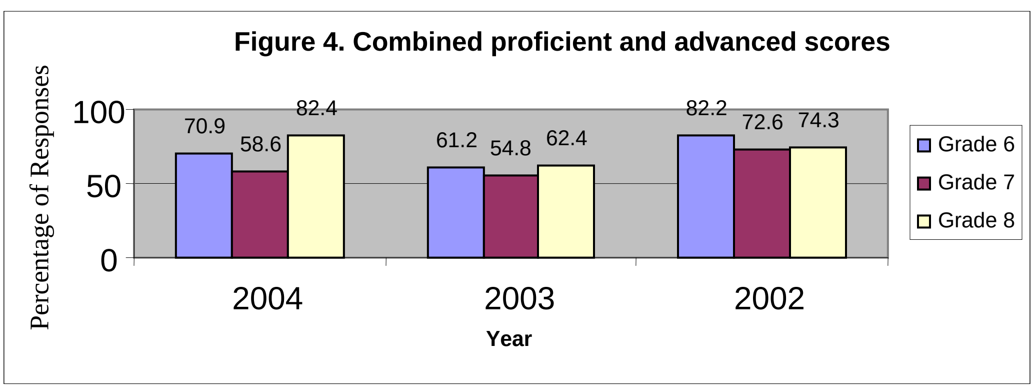
Classroom 2



Classroom 3



Classroom 4



School Improvement and Lesson Plans

School improvement plans were viewed in an attempt to evidence the appearance of the three essential components used to address learning styles. The plans served as evidence of the components that were to be implemented. Lesson plans were also viewed during classroom observations to determine if the three essential components used in addressing learning styles were included.

Findings

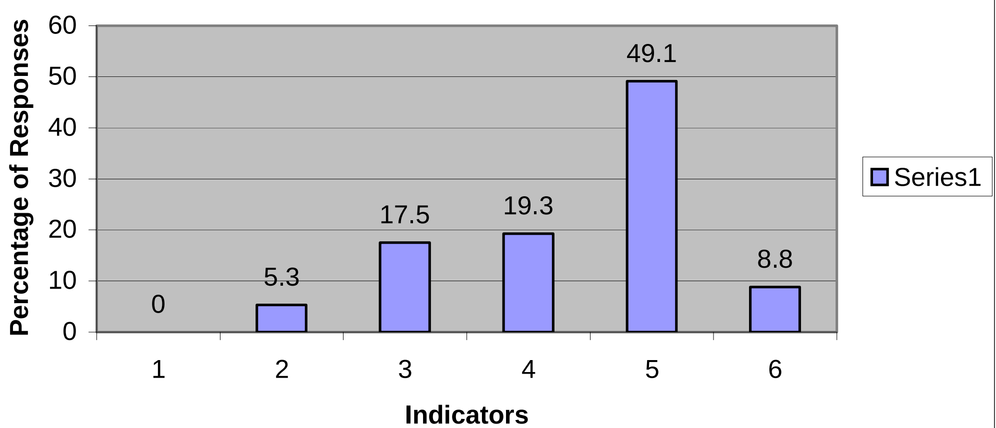
The findings included the responses from the 57 returned questionnaires, personal interviews, observations of the classrooms, school improvement plans and lesson plans only as they pertained to areas that were selected for analysis.

Question 1: On a scale from 0-5, with 5 indicating all components (visual, auditory, kinesthetic) addressed along with suggestions and 0 indicating that not any components were addressed, to what extent do you consider learning styles to be addressed in your School's Improvement Plan?

Results included 28 (49.1%) teachers checking 5, 11 (19.3%) checking 4, 10 (17.5%) checking 3, 3 (5.3%) teachers checking 2, and 0 (0.0%) checking 1. Five (8.8%) teachers did not respond to the question, indicated by the number 6 (see Figure 5).

A review of school improvement plans showed that only 1 of 4 schools observed addressed the three components essential to addressing learning styles and provided suggestions as to implementation.

Figure 5. Learning styles addressed in SIP

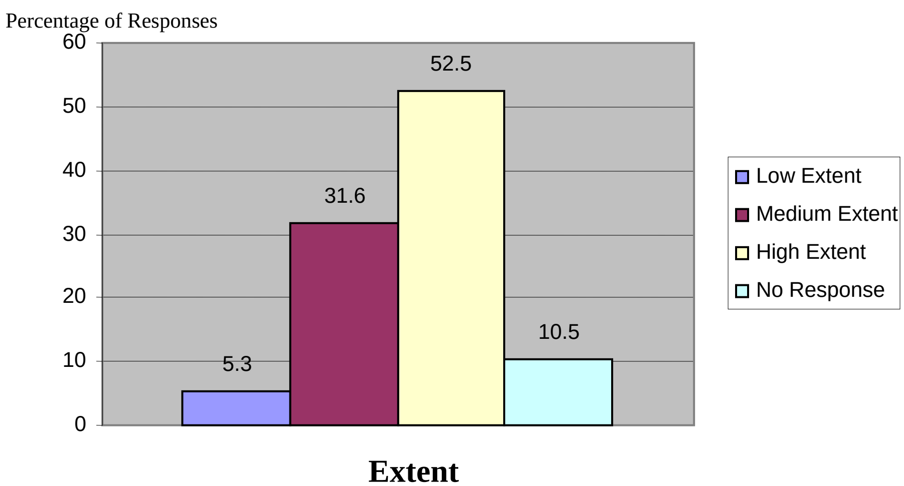


Question 2: To what extent are you addressing learning styles in your weekly mathematics lesson plans?

Thirty (52.5%) teachers were addressing learning styles to a high extent (addressing the three components), 18 (31.6%) teachers were addressing learning styles to a medium extent (addressing two components), and 3 (5.3%) teachers were addressing learning styles to a low extent (addressing only one component). Six (10.5%) teachers did not respond to the question (see Figure 6).

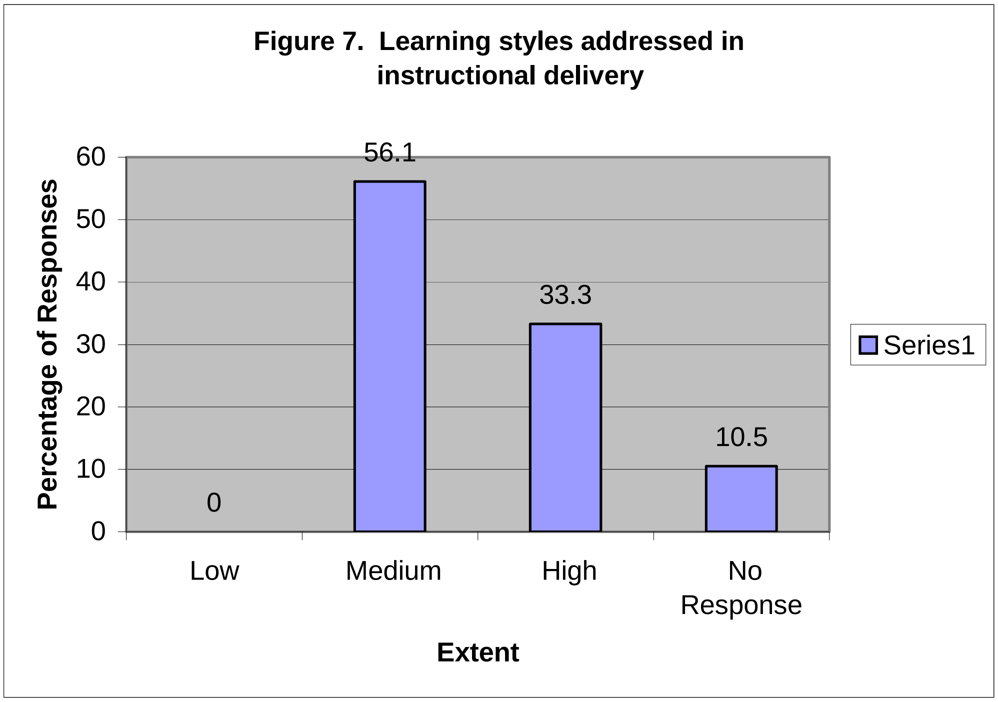
When lesson plans were examined, evidence was found that 3 of 3 plans addressed learning styles to a high extent. All plans included a target objective, procedures that were followed to accomplish the objective, teaching strategies that were used, and the learning style approaches that were addressed.

Figure 6. Learning styles in lesson plans



Question 3: To what extent are you addressing learning styles in your instructional delivery?

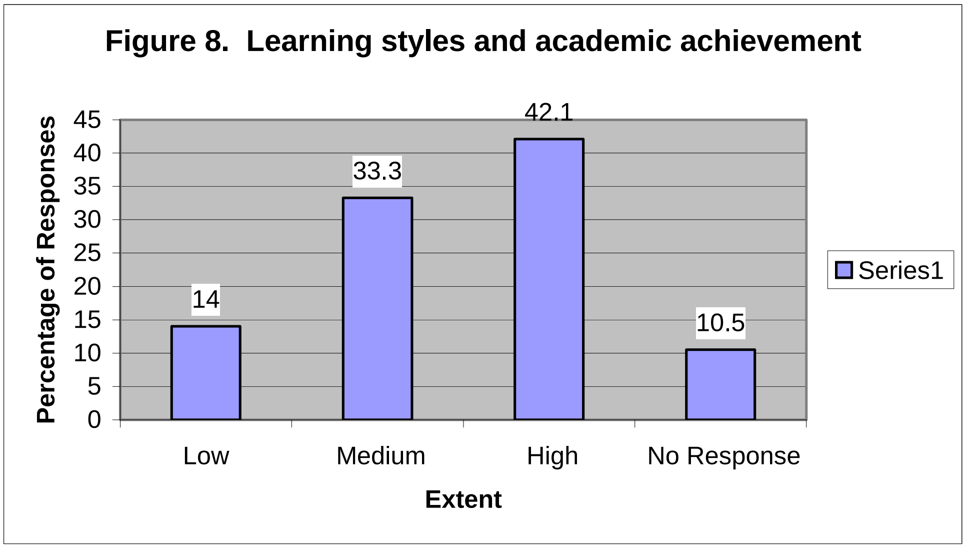
Nineteen (33.3%) teachers reported addressing learning styles at a high extent (addressing three components), 32 (56.1%) reported addressing learning styles to a medium extent (addressing only two components), 0 (0.0%) reported addressing learning styles to a low extent, while 6 (10.5%) did not respond to the question (see Figure 7).



When instructional delivery was observed, 4 of 4 teachers addressed all three components. The following is an example, when introducing radical expressions, the teacher first orally and visually explained the properties for simplifying radicals and rationalizing the denominator by providing examples and explaining the problem-solving techniques (**auditory/visual**). Students were then asked to copy notes from the board and discuss the examples provided by the teacher (**kinesthetic/auditory**). Students were given problems to solve where they received one-on-one instruction from the teacher and assistance from peer tutors (**kinesthetic/auditory/visual**).

Question 4: To what extent are you addressing the learning styles of students when assessing their academic achievement?

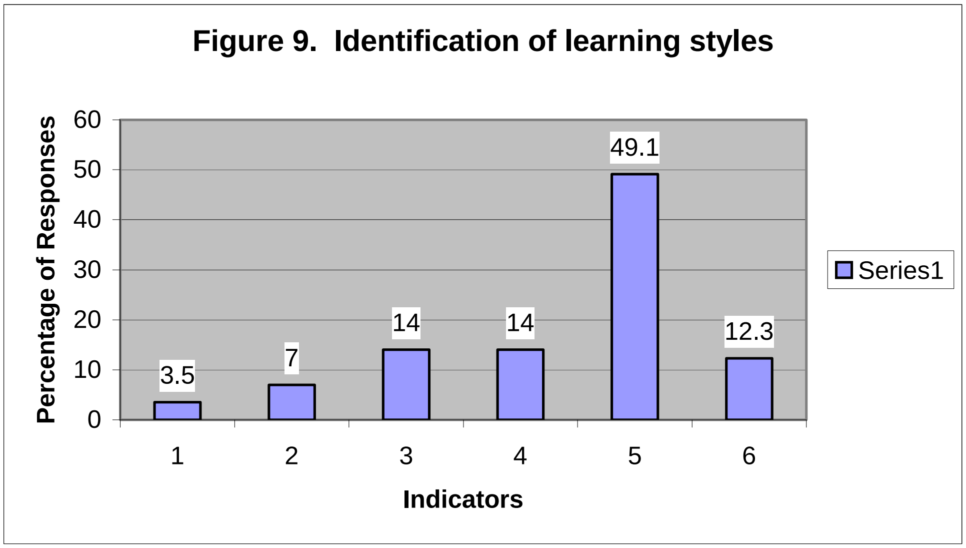
Twenty-four (42.1%) teachers reported that they addressed learning styles in accessing academic performance at a high extent (addressing three components), 19 (33.3%) addressed learning styles to a medium extent (addressing only two components), 8 (14.0%) addressed learning styles at a low percent (addressing only one component), and 6 (10.5%) did not address the question at all (see Figure 8).



During the classroom observations, 4 of 4 teachers provided weekly tests that were used to assess the mathematics achievement of students. For each test, teachers reported that oral along with written directions were provided to students. For students whose learning styles were of a kinesthetic nature, number boards, manipulatives, computers, and calculators were presented to them to complete the test. Teachers also reported that for some students that they have taught in the past, tape recorders were used, students responded to test questions orally instead of written, overhead projectors were used to draw pictures rather than use numbers and that rule charts were presented to students to assist them with the completion and passing of tests, classroom tasks and homework assignments.

Question 5: What method(s) do you use to identify the learning styles of students?

Twenty-eight (49.1%) reported that students' learning styles are identified through observations, 8 (14.0%) reported identifying learning styles through observations along with the use of a Learning Style Inventory, 8 (14.0%) reported identifying learning styles using student questionnaires and through observations, 4 (7.0%) reported using multiple methods (learning style inventories, student questionnaire, observation, other methods) to identify learning styles, 2 (3.5%) reported using a learning style inventory only to identify learning styles, and 7 (12.3%) teachers did not respond to the question (see Figure 9).



Question 6: In your opinion, when learning styles are addressed in your classroom, what impact, if any, does this have on student's mathematics performance? Briefly explain your response through testimonials, examples, etc.

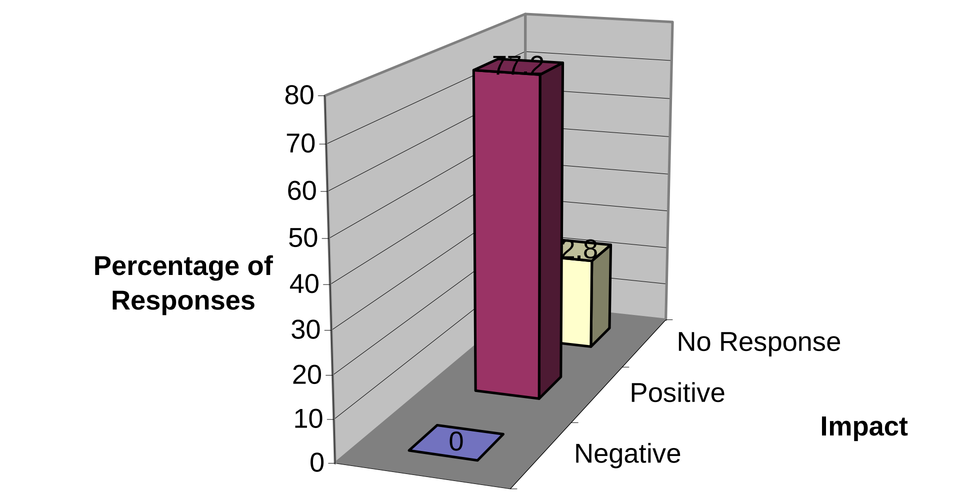
Forty-four (77.2%) reported a positive rationale of the impact of addressing learning styles of mathematics performance, while 13 (22.8%) did not respond to the question. Testimonies and examples included "I have incorporated all the learning styles in my classroom. Learning styles such as visual, auditory, and kinesthetic are used daily in my lesson presentation. Experience has taught me that students retain more when they are allowed to become physically involved in the skill being taught. When a variety of learning styles are used in a lesson taught, students test scores are also better." "One student did not understand when lecturing, so I showed him hands-on. The student explored how to subtract integers by using counters." "A student's mathematics performance is greatly impacted when learning styles are addressed. My students need to see how a problem is solved along with an explanation of the steps. Also, students tend to remember longer when we have hands-on activities" (see Figure 10).

Interview questions revealed that 4 of 4 teachers were teaching at their various schools during the years 2001-2004 and that they all were addressing learning styles during those years. However, there were differences in opinions as to why MCT test scores were up and down during those years.

One teacher reported "the school has a great deal of low level students and that a small percentage of these students can bring down test scores. As long as students' score at the advanced and proficient level, scores basically remain the same, however, if a few scores drop to basic or minimal level, scores drop for the homeroom and bring down school scores."

Another teacher reported that there is a "difference in kids. Sometimes you have a better group of students as a whole. Kids will allow you to teach to a certain point, and then they shut down." The teacher further stated "when students are taught specifically for the purpose of passing a test, it is harder for them to make adjustment to the next class level."

Figure 10. Impact of learning styles on mathematics achievement



Two teachers chose not to comment on the increase/decrease in scores.

Summary

When learning styles are addressed, does this practice serve to increase mathematics performance in the classroom and on high stakes tests? The literature suggests that when learning styles are addressed, students perform better academically. In addition, middle school mathematics teachers agree with the learning styles approach to enhance academic achievement.

Overall, a total of 89.5% of middle school mathematics teachers working in schools in the Mississippi Delta are addressing learning styles to some extent. Fifty-two percent of middle school mathematics teachers are addressing learning styles at a high extent, meaning that a visual, auditory and kinesthetic component, as defined by this evaluation, are being used in class to promote mathematics academic achievement. A review of selected lessons plans further evidenced this technique. Lesson plans contained components such as: use of newspaper ads to find the total cost of items; students being called on to solve problems from the board and explain the steps;

instructions being provided verbally as well as written; question and answer sessions; use of computers along with calculators to assist in solving problems; students completing projects; and having the opportunity to express themselves verbally rather than only in writing.

Though 49.1% of teachers indicated that learning styles were addressed in their school improvement plan, a review of a selected group of school improvement plans found that only 1 of 4 plans included learning style components along with suggestions as to how they would be implemented. The remaining selected group of teachers may have been among those 8.8% of teachers who did not respond to the question.

Teachers (33.3%) also reported addressing learning styles in their instructional delivery. From a classroom observation conducted on a selected group of middle school mathematics teachers, the evaluator was seeking to find teachers using visual (pictures, diagrams, slides), auditory (verbal instructions, dialogs, tape recorders), and kinesthetic (small group, concrete objects, exhibits) components in instructional delivery. The observation revealed that 3/3 teachers were addressing all components in their delivery. In one class, the class objective was to simplify complex numbers. The teacher, who already had problems on the board, used the visual and auditory component to show students how the problems should be solve by demonstrating steps and talking them through for the students. He then asked students to come to the board and follow the same procedures whiles instituting the kinesthetic components by allowing students at their desk to solve the problems using their calculators.

When assessing students' academic achievement in math, 42.1% of teachers reported addressing learning styles to a high extent indicating that all the essential components were used. During classroom observations conducted on a selected group, all teachers reported the use of verbal and written directions, allowing students to use calculators, question and answer sessions for clarification, and the use of an overhead projector. A review of one teacher-made test showed directions written in words and symbols, items where students drew the correct answer, test items written in bold type, and words of encouragement written in somewhat of a three dimensional format.

Identifying learning styles of students appeared to be a simple process for middle schools mathematics teachers. Observations were the primary source of identification as reported by 49.1% of the teachers. Other methods of identification included learning style inventories and student questionnaires.

Middle school mathematics teachers seem to think that when learning styles are addressed, there is a positive impact on mathematics performance. Teachers (77.2%) reported positive rationales as they pertain to the impact of learning styles on academic achievement. Teachers reported on the visual aspect of addressing learning styles, the auditory aspect, kinesthetic involvement, experiences addressing learning styles, and how addressing learning styles in a variety of ways, during one lesson, enhances academic achievement.

State test results were reviewed for this selected group and indicated that 2 out of the 4 schools' combined proficient and advanced scores were above 50% for the school years 2001-2004. Scores for classroom 2 were above 50% for grades 6 and 8 in the 2004 school year. Scores fluctuated over the years for grade 7 with the highest combined score reported at 35.7% for the 2003 school year. Scores for classroom 3 were above 50% for grade 6 for all years and fluctuated over the years for grade 7 with the highest combined score reported in the 2002-2003 school year at 75%. Scores also fluctuated for grade 8 with the highest combined score reported in the 2003-2004 school year at 96%.

In conclusion, it appears that addressing learning styles may have some impact on high stakes testing and classroom academic achievement as evidenced from middle school mathematics teachers in the Mississippi Delta area through surveys, oral reports, classroom observations, review of lesson plans, school improvement plans and state test. All teachers appear to be addressing learning styles to some extent and have reported that the approaches being used are working to increase academic achievement. Learning styles are being addressed in lesson plans, instructional delivery and assessment. Teachers are making a special effort to identify learning styles for students and implement the corresponding activities to enhance learning. Teachers are also being trained by the state to address learning styles and maintain a positive rationale for doing so. This suggests that teachers are receiving more information on addressing learning styles and believe that it is important that they continue do so in attempting to increase academic performance in students.

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