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 Biggs (1996) however argues that memorizing may result in deep learning albeit using an approach regarded as outdated by current Western pedagogy.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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