FELDER'S LEARNING STYLES, BLOOM'S TAXONOMY, AND THE KOLB LEARNING CYCLE: TYING IT ALL TOGETHER IN THE CS2 COURSE

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INTRODUCTION

One problem that faces computer science teachers today, and teachers everywhere, is that the process of teaching well is no longer as simple as standing in front of a classroom and lecturing for 55 minutes. Professional educators must choose between the myriad of educational tools and techniques available to them that over the years have proven to enhance the student learning experience. The following short list presents some of the most promising.

Educators have long considered the Bloom Taxonomy of Learning to be a valid benchmark that measures a student's level of understanding in a particular subject [1].

Richard Felder has shown that both students and teachers prefer specific learning styles, among many, in which they are comfortable receiving and giving information. Teachers that subscribe to this idea by presenting their coursework in all of Felder's Learning Styles have improved the effectiveness of their teaching [3].

The Kolb Learning Cycle is another model, similar to Felder's Learning Styles, that describes how student's learn. Harb and Terry have shown that teaching through the Kolb Cycle is an effective way to reach all of the students in a classroom [5].

Paricia Cross has shown that the Minute Paper is a simple but effective tool available to educators that forces students to consider the deeper levels of understanding within a particular subject [2].

Felder and Brent have shown that structuring coursework around the Cooperative Learning model is an effective technique for increasing their student's level of understanding [4].

How do today's teachers incorporate these many teaching tools into one, single 55 minute class and then sustain those ideas over an entire semester? This paper presents a blueprint to do just that in the traditional CS2 course[1].

BACKGROUND

The CS2 Course. The CS2 course is a structured programming course that covers basic data structures, abstract data types and recursive algorithms. Students examine the distnction between traditional top-down desgin using abstract data types and object oriented design using classes. Students use C and C++ as the language tools on both the DOS/Windows and UNIX platforms. Before constructing a general course blueprint, a review of the various teaching tools and techniques is in order.

Bloom's Taxonomy of Learning. Bloom's Taxonomy of Learning is a hierarchical representation of the students depth of knowledge in a given subject or cognitive domain (See Figure 1) [1]. Knowledge, the first layer, represents the student's lowest level of learning within the subject matter. Students that memorize facts for an exam have attained this level in the hierarchy. Evaluation represents the opposite end of the spectrum. Students that can determine the better solution in the problem domain among many possible solutions have reached this highest level in the taxonomy. Teachers should strive to guide their students to the higher levels of the taxonomy as much as

[1]The views expressed herin are those of the author and do not purport to reflect the position of the United States Military Academy, The Department of the Army or the Department of Defense

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Level 1 - Knowledge: Fact recall with no real understanding behind the meaning of the fact.

Level 2 - Comprehension: The ability to grasp the meaning of the material.

Level 3 - Application: The ability to use learned material in new and concrete situations.

Level 4 - Analysis: The ability to break a complex problem into parts.

Level 5 - Synthesis: The ability to put parts to gather to create a unique new entity.

Level 6 - Evaluation: The ability to judge the value of the material for a given purpose.

Figure 1 - Bloom's Taxonomy of Cognitive Objectives

possible [1]. In this manner, the student may reach a deeper understanding of the subject matter.

Felder's Learning Model. Felder's Learning Model categorizes an individual's preferred learning style along a sliding scale of four dimensions (See Figure 2) [3]. Each row represents a learning dimension. For example, by placing a student or a teacher on the scale of the Active-Reflective dimension, educators can tell how much students like to actively participate in the learning process or instead prefer to observe and think about it[2]. Placing teachers and students along the other dimensions gives us other useful information.

There is no correct learning style. There is simply a preferred style. According to Felder, students and teachers may prefer one side of a dimension in one subject and the opposite side in another; but, generally, they prefer one side or the other in most subjects [3].

Teachers can use this information to make sure they are reaching all the different learning dimensions in a course. Students can use this information by realizing how they like to receive information, analyzing how the teacher is presenting the information and resolving any style conflicts by completing supplemental work or asking the teacher to explain certain points in a different manner.

The Kolb Learning Cycle. The Kolb Learning Cycle provides another method to address different learning styles [5]. Similar to Felder's Learning Styles, the Kolb model places students within one of four quadrants (See Figure 3). The left and right quadrants correspond directly to Felder's Active-Reflective scale. The top and bottom quadrants correspond directly to Felder's Sensing-Intuitive scale. The

[2] Felder is currently testing a mechanism that will place a student along each dimension.

Definitions	Dimensions		Definitions
Do it	***Active***	***Reflective***	**Think about it**
Learn Facts	***Sensing***	***Intuitive***	**Learn Concepts**
Require Pictures	***Visual***	***Verbal***	**Require Reading or Lecture**
Step by Step	***Sequential***	***Global***	**Big Picture**

Figure 2 - Felder's Learning Dimensions

Kolb model does not directly address Felder's Visual-Verbal scale or the Sequential-Global scale. Still, the model is useful in the classroom.

The "why" student wants to know why the current subject is important. The "what" student wants to know the facts about the subject. The "how" student wants to know how to apply the subject to real problems. Finally, the "what if" student wants to experiment with different possibilities. Harb and Terry believe that if an instructor "Teaches around the Circle" by starting in the "why" quadrant and ending in the "what if" quadrant", then the needs of all the learners are met [5].

Cooperative Learrning. The educational community has long established the effectiveness of Cooperative Learning [6]. According to Felder and Brent, Cooperative Learning is not simply placing students in groups and assigning the group a problem to solve. Instead, a Cooperative Learning environment must have five essential elements (See Figure 4). Only if the cooperative learning exercise contains these elements will the exercise be successful.

Minute Paper. Charles Schwartz, a professor from the University of California at Berkeley, proposed the Minute Paper. At the end of each class, Schwarts asked his students to address the two questions listed in Figure 5. When Cross used this technique in her own classes, she found that her students initial minute papers focused at the

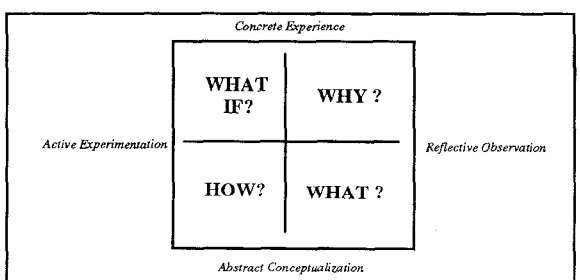

Figure 3 - Kolb Experimental Learning Cycle

1. *Positive Interdependence* - If one team member fails, the entire team suffers.

2. *Individual Accountability* - Each team member is responsible for the all aspects of the group problem and individually accountable for his portion.

3. *Face-to-Face Promotive Interaction* - Group work completed as a group and not parceled out for individual completion.

4. *Appropriate Use of Collaborative Skills* - Group members are taught trust-building, leadership, decision-making, communication and conflict-management skills.

4. *Group Processing* - Group members establish team goals, evaluate progress and make changes appropriately.

Figure 4 - Cooperative Learning Elements

low end of the Bloom Taxonomy. As the semester progressed and she gave feedback in class by reading typical student submissions, she found that the students began to travel on their own to the deeper levels of the Bloom Taxonomy [2].

COURSE BLUEPRINT

Lesson Objectives. The first step in developing the course blueprint is to design the lesson objectives for the course. In CS387, the students attend 40 lessons; so, the instructors constructed 40 sets of lesson objectives. The key point here is each lesson objective is couched in terms of Bloom's Taxonomy. Figure 6 shows some typical lesson objectives for a lesson. Notice that each lesson objective corresponds to a specific level in the Bloom Model. On lesson one of the course, the students receive an overview of the Bloom Taxonomy and the subtleties of understanding a subject on the different levels.

Most lesson objective sets begin with a number of *knowledge* type questions. Later objectives begin to move down the taxonomy. It is difficult to reach the Evaluation level of the taxonomy on every lesson; but, it is important to move down the taxonomy over a series of lessons. Figure 7 shows the deepest level on Bloom's taxonomy that each lesson in CS387 attains over the semester. The lessons that register a zero were either drops for project work or opened ended review sessions with no specific lesson objectives. Over 40 lessons, CS387 manages to

1. *What was the most important thing you learned today?*

2. *What questions are upper most in your mind?*

Figure 5 - Minute Paper Questions

Lesson 15 - Merge and Quick Sorts:

Lesson Objectives:

1. The student will **know** how the merge sort works.
2. The student will **know** how the quicksort works.
3. The student will **comprehend** the Big O analysis of merge sort and quicksort.
4. The student will **evaluate** the five sorting methods covered in Kruse, Chapter 7, for both contiguous and linked lists in terms of Storage Space, Running Time and Programming Effort.

Figure 6 - Lesson Objectives in Terms of Bloom's Taxonomy

reach the Evaluation plateau on the Bloom Taxonomy on four separate occasions: Lessons 1 - 8, Lessons 9 - 15, Lessons 16 - 29 and Lessons 31 - 40.

Cooperative Learning Teams. The next step is to formulate the cooperative learning team assignments. In CS387, the teams will work together on homework problems and a case study conducted over two lessons.

Homework for the class is ungraded; but, four times throughout the semester, we give the students a quiz that consists of one or two of the homework problems verbatim. If the everyone on a team receives a B average or better, then everyone on the team will receive a half letter upgrade to their current programming assignment grade; coincidentally due in the next lesson. We conduct the case study over two lessons with a similar incentive grade.

For each homework set, four in all throughout the semester, and the case study, we assign a team leader and a team secretary. The team leader's job is to resolve disputes in the group as they turn up and set the team's goals. The team secretary's job is to schedule meetings and to make sure all the administrative requirements are met. All team members are required to teach the group the solution to some portion of the homework set. At the midway point, the team submits a progress report that explains if they are meeting their goals and any corrections they are making to insure success.

Teach around the Circle. The next step is to outline the presentation of each class. To prepare the lesson of the day, the instructor uses the Kolb Learning Cycle as an outline (See Figure 3). We usually begin with the "Why" quadrant. This gives the student the motivation as to why he is studying the material. It also gives Felder's global learner the big picture before the instructor steps through the material in the style that the sequential learner prefers.

Next the instructor moves to the "What" quadrant. Here he explains the general terminology of the subject at hand. As such, the students reach the first and second levels of the Bloom Taxonomy: Knowledge and Comprehension. Further, this kind of material appeals to the sensing learner in Felder's model.

The teacher then moves to the "How" quadrant. Here he are looking at how to utilize the general knowledge the students have gained in specific problems. By moving into this quadrant, the teacher moves the student further down the Bloom Taxonomy: Application and Analysis. Felder's intuitive learners are more comfortable here then they were in the previous quadrant.

Finally the teacher moves into the "What if" quadrant. Typically, this quadrant is the bridge between the current topic and the next. A typical transition follows: What if we changed the current problem to include the following new parameters? This allows the student to synthesize and evaluate the current topic: the last two levels of the Bloom Taxonomy. The teacher also supplements these two levels with examinations and programming projects that ask the students to solve synthesis and evaluation type questions. Again, this kind of material appeals to the intuitive learner in Felder's model.

As was stated before, CS387 manages to complete the teaching circle about every 10 lessons (See Figure 7). In the process, the instructors can move their students to the deepest levels of the Bloom Taxonomy and reach roughly half of the learner's in Felder's model: global, sequential, sensing and intuitive. What about the other half?

Side Trips along the Circle. The last step is to gather up the remaining learners in the Felder model and to hammer home the Bloom depth chart for the current lesson.

Verbal learners are easily accommodated through the standard lecture style used in most classes. They prefer receiving information in this style or from reding the course book. Visual learners are harder to reach. Still, the CS2 curriculum is rich with examples that can be visually demonstrated. Instructors are using Autodesk's Animator Studio to animate the different algorithms covered in the course. When the instructors talk about how the insertion sort works for example, they demonstrate an animation of the actual algorithm.

The instructor will stop the lecture at key points in the lecture to discuss an appropriate homework problem. To accommodate the reflective learner, the instructor will ask one of the cooperative learning teams to present their solution to the problem. This has two effects. It gives Felder's reflective learner a moment to pause and to consider the subject without the instructor moving to the next topic. It also has the side effect of insuring that the homework teams are keeping up with the assignments.

To accommodate the active learner, we dedicate 20 to 30 minutes of each class to Windshield time on the computer. Each student has their own workstation in the classroom. This CS2 course uses the Borland C++ 4.5 compiler. During each lesson, the instructor asks the students to solve some small programming problem pertinent to the current subject. Windshield time is the hands-on time the student spends solving some programming problem in front of the computer monitor

Finally, the courses uses a modification of Schwarts's Minute Paper idea. Instead of having the student write down the answers to the questions listed in Figure 5 at the

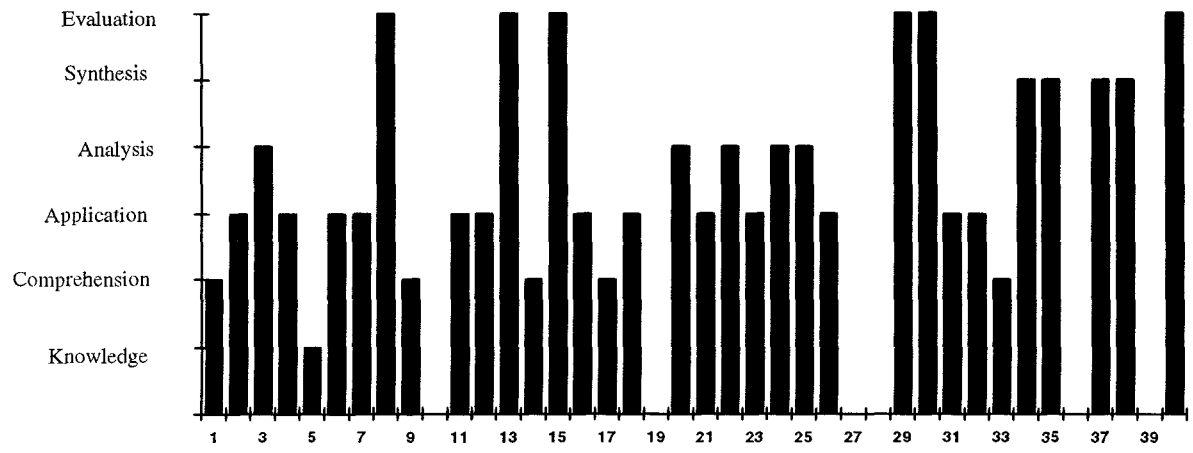

Figure 7 - CS387 Bloom Taxononomy Depth Per Lesson

end of each lesson, the teacher gives the students a short graded quiz. The quizzes are called Attention Quizzes and are generally no more then one or two questions, usually True/False or multiple choice[9]. Since CS387 designed up front with Bloom's Taxonomy in mind and the instructors teach around the Kolb Learning Cycle, the Attention Quiz has the same effect as the Minute Paper. It provides useful feedback to the instructor as to how well the students are following the material and, more importantly, forces the student to reach for the deeper levels of the cognitive domain. One additional benefit the Attention Quiz has over the Minute Paper is that it rivets the student's attention during the class. Student interest levels are elevated significantly when they know that the teacher will grade their answer to one question concerning the previous hour's lecture.

CONCLUSIONS

Educators are aware of the many techniques and tools available to improve student performance in the classroom. Some may think that there are so many that the very idea of incorporating one or more into the classroom is overwhelming. This paper has shown that this is not the case. It is possible to sustain a course over an entire semester with the lofty goals of reaching the many preferred leaning styles of your students and at the same time guiding them to the deeper levels of your subject's cognitive domain.

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