Alternative Learning Methods to the Traditional Lecture Approach in the Computer and Information Sciences Disciplines

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Abstract

This paper will present various alternative learning approaches that have been used to supplement the standard lecture approach to the teaching of new concepts in the Computer and Information Sciences disciplines. One approach includes students as acting participants in the delivery of the new concept. Another approach includes "hands-on" learning of the new theory. A third approach incorporates visual learning concepts. Even students who can easily comprehend new material benefit from visual tools that affirm and increase the depth of their understanding of concepts presented. A final approach uses guest speakers from industry whose career reflects the subject matter of the course. The speakers can provide information, give advice, and answer questions about career related topics; thereby, enriching students' perspectives on various career paths. The guest speaker often reinforces material that has been presented or challenging assignments that have been assigned by the professor.

Computer and Information Science courses which have been taught using these approaches include: Introductory Computer Science, Programming courses, Information Management, Systems Analysis and Design, and Simulation and Modeling. This paper will provide specific examples of the alternative learning approaches used in those courses. Assessment of the students' knowledge gained through the alternative delivery of course material will also be discussed. Some assessments have been given during the actual delivery to increase the students' attention; thereby, increasing their retention of the new material. Other assessments have been done through a follow up question and answer session, an immediate quiz, a written summary, or as test questions.

In summary, this paper will present alternative learning methods to the traditional lecture approach in Computer and Information Science courses and provide specific assessments used during or following their delivery. This provides feedback to the professor on the success of the student's retention and comprehension of the material.

I. Introduction

Alternative learning methods to the traditional lecture approach have been used to teach

new concepts in Computer and Information Sciences courses. This paper will present several different alternative instructional delivery approaches. First, an approach which uses students as active participants in the delivery of a new algorithm will be discussed. Students were selected by the instructor to represent various components such as data, memory locations, and pointers. Sorting algorithms were taught in programming courses in such a manner. A second approach discussed in this paper includes "hands-on" learning of new theory. Students often have difficulty grasping the concept of recursion when first introduced to it. This paper will discuss how a physical demonstration of a popular recursive example was used in teaching recursion in programming courses. Mathematical probability theory used in a Simulation and Modeling course was also reviewed using physical demonstrations. The expression, "a picture paints a thousand words", is the idea behind a fourth approach which employs a visual learning approach. The most common visual method used to supplement traditional lecture methods is by showing a video on related material. Another method is to provide supplemental handouts with a picture tutorial of the topic. Several courses were supplemented with visual materials including Introductory Computer Science, Programming, and Information Management. The challenge in using such materials is to ensure students are attentive and will retain important concepts of relevance. Various assessments used with the visual approach will be discussed. Finally, the use of industry guest speakers in various courses will be discussed. A need for academia to establish business links was identified by a task force established by Harold "Red" Poling, Former CEO of Ford Motor company and Chairman of the Business-Higher Education Forum, in 1997 with specific recommendations for higher education institutions to follow in closing the gap that exists between the needs of the work place and academic practices.[1] The use of industry guest speakers is one such business link that can narrow that gap. Courses in the discipline in which guest speakers have been used are Programming, Information Management, and Systems Analysis and Design.

Various means of assessing the students' retention of material taught through alternative learning methods will be discussed with the different approaches. To increase students' attentions during the presentation of the material, some assessments are administered during the actual delivery. Students' retention of material presented is higher in such cases. Other assessments are given shortly afterwards in different formats such as question and answer sessions or quizzes. Some assessments require reflection in the form of a written summary or as questions on a test. No matter what form the assessment takes, it is up to the instructor to use the results to determine the success of the alternative delivery method.

In summary, it is the goal of this paper to offer alternative learning methods to the traditional lecture approach in the Computer and Information Sciences disciplines. It is hoped that the insight and experience of having used these methods will foster ideas for others who want to provide alternative delivery of material into their courses. This in turn strengthens academic programs with students who cannot learn some concepts through a traditional lecture approach, but can through an alternative delivery method. The benefits are realized through retention of students, higher outcomes assessment scores, and alumni who are more likely to give back to the program monetarily or by giving of their time as an industry guest speaker.

II. Students as Active Participants

Various methods can be used to teach programming logic. Flowcharts are illustrative. Pencil-pushing techniques can also be used to explain logic. Some students may not quite grasp the logic of a new algorithm when using these approaches. An alternative approach includes the

students acting out the logic of the algorithm. In introductory programming courses, this method is used to explain the logic of sorting algorithms before showing the students a flowchart or code. The instructor selects 5 students of various heights. The students stand before the class and represent data that is to be sorted. Other students are asked to act as memory locations such as the current index, selected position, or a pointer. The students are then put into a sorted order by height from smallest to largest using the logic of various sorting algorithms such as selection sort, bubble sort, and insertion sort. After sorting the students by height, the instructor then pencil pushes through the sorting algorithm using 5 numbers. The class must follow the code and tell the instructor the next step in the algorithm as this is done. Using the traditional lecture approach, few students would participate or understand the various sorting algorithms the first time they were introduced. After incorporating this alternative approach, most, if not all of the students would participate in the pencil pushing of the logic. The students are then given a programming assignment to incorporate the sorting algorithm. As a means of assessment of the student's understanding of the sorting logic, the instructor includes a test question in which the students must show the first ten values generated in memory by pencil pushing through the algorithm. The students must complete a table in which the rows are specific memory locations and the columns are numbered one through ten. The students are given five values to sort. Only one value that is generated in memory must be placed in each column. The first value is placed in column one, the second value in column two, and so on. Generally, the first pass of the sort uses eight or nine of the columns. The remaining columns start the second pass of the sort. This assessment method has been very effective in determining the students who truly understand the logic of the sorting algorithm. Students who cannot successfully complete the table obviously do not understand how to pencil push through the logic of an algorithm. Because the instructor demonstrates how to pencil push through code on a regular basis in the course, students become quite proficient at doing so. All of the students attempt the question with most of the students getting it right. Those students who do make a mistake fall into two categories. The first group generally makes an error due to carelessness, such as accidentally putting two values in the same column. The second group is generally those who have put forth little or no effort in attending the class or working on their program assignments. In the latter case, the assessment works in correctly identifying their inability to understand the sorting logic.

III. Hands-on Learning

This section describes a second alternative learning approach that gives the students the opportunity to have a "hands-on" experience. This approach has been used in programming courses to teach recursion and to review the mathematics behind simulation and modeling techniques.

Recursion is not the easiest topic for students to grasp the first time they are introduced to it. A common legend used as an example of problem solving using recursion is the Towers of Hanoi. In addition to giving the students handouts showing a memory trace of activation records, the instructor has allowed the students to have a "hands-on" experience with a replica of a reduced version of the Towers of Hanoi. At first, the instructor used straws affixed to the lecture podium with clay as the towers labeled A, B, and C. Styrofoam disks of increasing sizes labeled 1 through 5 represented the stone disks. A student was selected to move the Styrofoam disks as the

instructor stepped through the recursive algorithm using 3 disks. Students would enthusiastically volunteer to assist as 4 and 5 disks were demonstrated. This stationary model worked quite well for several years. Then the instructor found a portable wooden model to use in the classroom which could be passed around the room or used conveniently if a student came by the office. The divide-and-conquer strategy of simplifying the problem to moving n-1 disks to a temporary hold, moving 1 disk to its destination, and moving the remaining n-1 disks to the destination is much easier to explain to students with a hands-on model. Some students who have been introduced to the topic previously comment how much clearer they understand it using a physical model. Some students have even constructed their own models out of toothpicks, paper, etc. to work through the logic outside of class. Students are given a program assignment which must be solved using recursion. In order to assess students' retention of recursion, students are asked to write a recursive function and show a memory trace of a recursive procedure that had not previously been covered in class. Since recursion is a more difficult concept than the sorting algorithms discussed in the last section, the ratio of success is not as high. Since the assessment is done in two different ways, code writing and memory tracing, the skill levels of various students can easily be determined. Generally no more than 30% of the students get both questions completely right. Up to 50% of the students get at least one of the questions right, with passing partial credit for the other question. 80 to 90% of the students get some partial credit on both questions. See Fig. 1-3. The remaining 10% are generally students who have not attempted the program assignment, have missed class regularly, and end up dropping, failing, or making a D in the course.

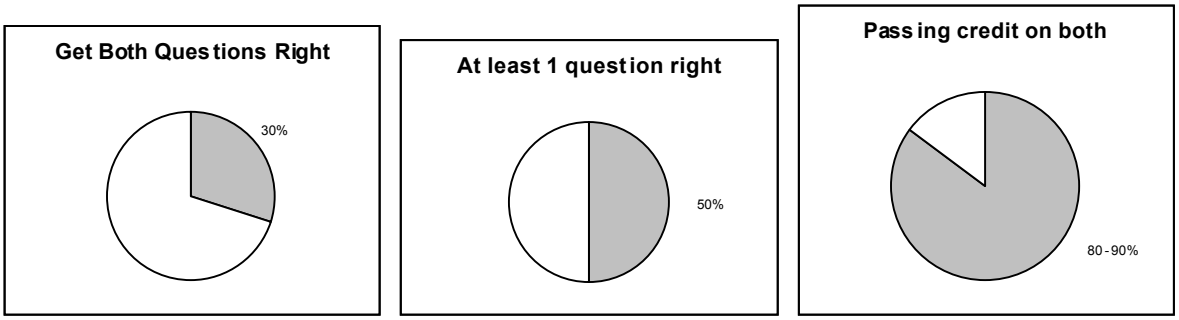

Fig 1 – 3. Recursion assessment results.

Simulation and Modeling uses a fair amount of probability theory. Since it may have been a few semesters since students took a statistics class, a "hands-on" approach is often a quick refresher for students. Simple items such as coins, dice and cards can be used in class to refresh students' knowledge of probability theory. In introducing various types of models, students are asked to construct a paper airplane model. Other types of model planes such as a Styrofoam model, and one with a motorized propeller are shown to the class. Various categories and aspects of models and what types of functionality are implemented by the models are then discussed including computer simulation models. Students are assessed on their understanding of this material by having to determine which category, what aspects, and what type of functionality is implemented by a described model on a test. In discussing random variables and cumulative distribution functions, the performance modeling text uses an example of throwing a dart at a sheet of paper. A real dart board is used in class as a hands-on illustrative example to explain the same material. Assessment of this material is done through a homework assignment based on the set of possible scores one can get on the dartboard. This is helpful in getting students to apply the

concepts of random variables and cumulative distribution functions sooner. Students are able to formulate questions on the topics as well. Simulating the numbers called in a bingo game is often used to discuss random number generators. A discussion of determining the winner in a simulated bingo game versus a simulated pokeno game can be difficult when students are unfamiliar with one or both of the games. By having the students play pokeno in class, students grasp the rules of play quicker. Students are then able to discuss various ways to implement aspects of the games and how to determine the winner in a simulation program. Students are assessed on their understanding of using random numbers through programming assignments. The benefits realized through these alternative learning methods are numerous. Students are much more relaxed, enthusiastic, and involved in the Simulation and Modeling class when these "hands-on" aids are used. Oftentimes, they serve as ice breakers as many students lighten up, smile, and laugh as planes and darts fly across the room or while they are playing a game. This is especially true of international students who are often more reserved in class than their American classmates. Since this alternative approach is used quite early in the semester, students are more at ease in asking questions and entering discussions as the topics get progressively harder throughout the semester. The importance of establishing open lines of communication in a course between the students and the instructor is essential to the learning process.

IV. Visual Learning Tools

Posters, pictures, devices, and videos can be used to supplement traditional lecture methods. As a student, not a single computer science professor used any type of visual aid in a class other than using an overhead projector. As an instructor, visual tools have always been used to supplement my lecture. Before the days of video and internet access, vacuum tubes, paper tape, punched cards, transistor circuit boards, and chips were passed around the room as the various generations of computers were covered. Posters showing the making of silicon chips and the care of 5 ¼" floppy disks were also brought as visual learning tools. A booklet was created containing pictures of early to modern computing devices and computer pioneers as a visual supplement to a history of computers lecture. Students could obtain a copy of the booklet at the library prior to the lecture and bring it to class. Today, the history of computers can be brought to life with a video. Students can also visit web sites full of historic computing devices and computer pioneers.

Students in programming courses have been shown the making of movies using computer animation such as *Toy Story 2* and *Star Wars: The Phantom Menace*. Even though the students' programs seem simplistic in comparison to the massive programs used to make the movies, the students become more excited about programming and what can be achieved using it after viewing the films. They also develop a deeper appreciation of the time spent on their own programs, as they learn it takes weeks for an animator to code tenths of a second of an animated film.

In an Information Management course, it is not possible to give students hands-on experience in large scale information systems. Students can see how companies such as Schneider National, Gateway, Fannie Mae, Boeing, and UPS use information systems in day-to-day operations through videos. Experience using Executive Support Systems (ESS) is not possible to

give students in a college course. Executives at companies such as Dupont, Frito-Lay, and Phillip-Morris share their experiences on video of how they did not grow up or even get to their current positions using computers, but now heavily rely on ESS to run world-wide operations.[2] Students learn about inheriting legacy systems that have been built as independent islands of technology and the challenge of managing them as discussed by various states' information services directors in a public television program video.

Assessment of using visual supplemental material can be done in various ways. An effective way to ensure students pay attention during the showing of the video is to give them questions with blanks that can be filled in as they watch the video. This can be collected immediately afterwards and graded. This type of assessment encourages students to pay attention during the video as many students may be tempted to study for another class, daydream, talk, or even sleep while it is shown. Another assessment method is a brief question and answer session after the video. Students are told in advance that they will be expected to participate. Students often take notes which help them to retain important key concepts. Other benefits derived from a discussion immediately following the video are; 1) the instructor can determine immediately the effectiveness of it in relating the key subject matter; and 2) the instructor can bring out key concepts which students may have not deemed as noteworthy. Finally, material may also be included on a test as a means of assessment.

The teaching of ethics in the computing field has been done using an integrated alternative approach in an Information Management course. Lockheed Martin advertised in a 1997 ASEE *Prism* issue that it had a limited supply of a complimentary Ethics Challenge game for academic programs. The game was developed by Lockheed Martin in collaboration with Scott Adams using DILBERT™ characters to perform ethics training for the employees of Lockheed Martin. This game was incorporated into the teaching of ethics in an Information Management course as "DILBERT Day". Prior to "DILBERT Day", DILBERT cartoons related to the current lecture topic or the computer field were read to the class during the semester. This allowed students unfamiliar with the comic strip to become familiar with the various characters of the comic strip. Students were also shown a video on how DILBERT's workplace attempted to deal with the Y2K problem. Students were asked to read the text chapter on Ethics as preparation for "DILBERT Day". Groups of 3 to 5 students were preassigned by the instructor for game playing teams. On "DILBERT Day" each team randomly picked a team card which corresponded to a DILBERT character playing piece representing DILBERT, Alice™, Wally™, Catbert™, Ratbert™, or The Boss™. A video featuring Dogbert™ was then shown explaining the rules of play. The instructor read various scenarios posing problems dealing with ethics such as copying company software, software misuse, use of e-mail, accepting gifts from computer vendors, and attendance at training courses. Each team received a copy of the scenario with 4 potential answers. The group discussed the topic and chose the answer that took the best course of action taking into account relevant ethical values. The objective cited in the leader's guidebook which accompanied the game is to stimulate thought, discussion, and analysis of ethical issues in the workplace[3]. The leader's guidebook provided a rationale for each potential answer which sometimes led to further discussion. The guidebook provided points ranging from 0 to 5 for the various answers. Each team moved its playing piece the corresponding number of spaces on the game board collecting tokens from various work locations such as the Boss' Office, Cafeteria,

Cubicles, Conference Room, Parking Lot, Lobby, Production, and Water Cooler. Landing on a Dogbert square resulted in a "Coffee Break" card which contained either a reward or penalty for ethics related actions. At the end of the class, all teams turned in their tokens to the instructor. On the next day of class, the instructor presented each team with a Certificate of Completion for taking The Ethics Challenge. Two teams were awarded bonus points and named as the "Most Ethical" team and the team with the "Most Tokens". Assessment of this integrated alternative approach has been done by using the points accumulated by each team as a grade and also by putting some of the scenarios on a test to determine students' retention of the material. On average 70% of the students correctly answer the questions on the test. See Fig. 4. The students who miss the questions generally select the same answer as they did in class on "DILBERT day" or were absent that day. Students have commented that they wished more of their courses would cover topics in such an engaging fun way.

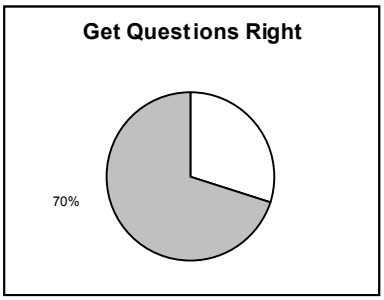

Fig 4. Ethics Assessment Results.

V. Industry Guest Speakers

Telling students about their future careers is one thing. Having a guest speaker from industry in the classroom providing information, giving advice, and answering questions about career related topics enriches students' perspectives on the career path they have chosen. Students often seem quite eager to ask questions of practitioners in the field. Guest speakers have reinforced material presented by the instructor and assignments given in the course. Establishing industry links directly in a class is important in keeping academia up-to-date with current Industry practices.[4] Students are also able to take advantage of any career opportunities which the speaker's company may have, such as internships, co-ops, or employment upon graduation.

An alumnus working as a programmer from Minolta-QMS, Inc. spoke to a C++ programming class. As a student, the alumnus had claimed that she would never become a programmer. After working as an intern testing printers for the company, an employee suggested that she apply for a programming job upon graduation. This alumnus was surprised to find that she actually enjoyed her daily work as a programmer. Students in the class realized that subjects they currently do not enjoy as students may become more enjoyable once in the workplace.

A CEO of a local Human Resource Services company spoke to an Information Management class. He discussed how his company incorporated information technology into its long term strategic planning. He first showed the students a strategic plan for his company from 5 years ago and discussed how the company fell short, met, or exceeded the plan in terms of its

information technology. The CEO then showed the students the company's long term strategic planning of information technology for the next 5 years. He was of the opinion, that the company would not have stayed as competitive or survived if it had not incorporated information technology into its planning process a decade ago. Many of his key points had been covered in the course. Instead of simply reading a case in the text, students now had a concrete example of those points in action with a real company. As a form of assessment, students were given questions on the test related to the subject matter covered in the CEO's talk. Students' retention of the material was higher than in semesters in which the material was just another day of traditional lecture.

A Systems Analyst working as an International Consultant for SAP spoke to a Systems Analysis and Design class. As a means of assessment students were asked to write a summary of his talk. The speaker had always wanted to teach a college course and was interested in reading the students' summaries. He wanted to find out what the students' retained and focused on in his talk as a means of feedback on the success of his delivery.

It is not always possible to find a guest speaker who is willing to give of his/her time to come speak to a college class. Often times, a speaker may make a commitment to speak and may have to cancel due to work obligations. Frequent communication prior to the date of appearance is the key to ensuring that things run smoothly. A prepared lecture to fall back upon is always necessary in the event of a last minute cancellation. The students are not the only ones who benefit from a guest speaker. The instructor often learns just as much, if not more than the students, from a guest speaker's talk. The benefits to the student and the instructor are well worth the investment of time taken to arrange such an event.

VI. Summary

This paper presented various alternative methods to the traditional lecture approach in various Computer Science and Computer Information Systems courses which are summarized in Table 1. Whether students are acting participants in algorithmic sorting logic, applying recursion in a "hands-on" fashion, gaining insight and enrichment while improving retention of subject matter through a visual presentation, or learning directly from a current practitioner in the field, these experiences bring an enthusiasm and excitement into the classroom that is often times missing in a straight forward lecture. It is important to include a means of assessment following the delivery of material using an alternative approach. This provides feedback on the success of the alternative method and a follow-up opportunity for further enrichment and learning of course topics. The drawbacks to these approaches are few. In most of the examples cited in this paper, students seem to pay more attention than during a traditional lecture. In the approach which uses videos as an alternative, it is easy for students to not pay attention. This is why it is important to provide an immediate assessment, such as distributing a form to be filled out while the video is shown, giving a quiz, having students write a summary or participate in a class discussion immediately afterwards. The potential exists for students' performances to drop, if only an alternative method is used. It is best to use multiple methods of delivery. One example is in covering the history of computers, a traditional lecture is given that refers to pictures of historic computing equipment and computing pioneers in a supplemental booklet followed by a video on

the same material. Another drawback is Murphy's Law prevails as equipment fails or a guest speaker cancels at the last minute. A backup plan is needed in those situations. Assessing the results of using the alternative approaches may show that a student's performance may not improve significantly than with a traditional lecture approach. The significant difference lies in the positive dynamic atmosphere that is created. So the question to consider is : "If students' scores aren't significantly improved by an alternative delivery approach, but the approach makes learning more fun, than why not at least supplement your lectures with one?"

Course	Topic	Alternative Approach	Assessment Method
Introductory Computer Science	History of Computers	Video Supplemental Booklet Visual aids	Fill in the blank form Test
Programming	Sorting Recursion Programming in general	Active participants Hands-on model Guest Speaker Video	Program, Test Program, Test Written Summary Discussion
Information Management	ESS Managing islands of technology Ethics Strategic Planning	Video Video Challenge Game Guest Speaker	Fill in the blank form Discussion Test Game Pts, Test Test
Systems Analysis and Design	Application Software Solution Providers	Guest Speaker	Written Summary
Simulation and Modeling	Probability Theory Types of Models Random Variables Random Numbers	Hands-on items Visual aids Dart board Pokeno Game	Homework, Test Test Homework, Test Program, Test

Table 1. Summary of Alternative Learning Methods and Assessments used.

VII. References

[1]"Spanning the Chasm: Corporate and Academic Cooperation to Improve Work-Force Preparation", Business-Higher Education Forum, January 1997, pg 1-10.

[2]Laudon, Kenneth C., and Jane P. Laudon, *Essentials of Management Information Systems* Video Series, Fifth Edition, Prentice Hall, 2001.

[3]"Leader's Guide", *Lockheed Martin's Ethics Challenge,* Cohen/Gebler Associates, Inc., 1997, pg *ii*.

[4]Nancy K. Gautier, "A Reporting Mechanism to Identify, Establish, and Modify Business/Industry Linkages", *Alabama Quality Award Conference Proceedings*, Tuscaloosa, Alabama, October 4-5, 2000.

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