Designing a Hybrid Breadth-first CS1 Course

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***Abstract* – With the cost of education rising, more no-traditional students returning to school and employers looking for students with experience beyond the classroom, institutions are evaluating how to best deliver the educational experience to today's student. The Babson Survey Group reported that in 2011, there were more than 6 million students enrolled in online courses. The report also stated that approximately one-third of all higher education students now take at least one online course with this number projected to grow. However, in higher education there still remains a debate on the merits of online courses versus the traditional face-to-face classroom experience. In response to this debate, many institutions now offer three modes of instruction which include traditional face-to-face, online and hybrid. Hybrid courses can be described as a blended method of face-to-face and online. However, there are challenges to designing a hybrid course, especially in the science, technology, engineering, and mathematics (STEM) areas. The aim of this paper is to present the design for a hybrid course in an introduction to computer science course taught a two-year institution. The course is a breadth-first course taken by majors, as well as students who need a course to substitute for a mathematics course, required as part of the common core curriculum. The uniqueness of the work is tri-fold: 1) the environment in which the course is offered; 2) the student population enrolled in the course; and, 3) the nature of the delivery mode. The paper presents the design of the course which includes course content and learning outcomes; the teaching pedagogy; course organization and how the course will be evaluated.**

Keywords – Hybrid learning; collaborative learning; learning content management system; undergraduate computer science

I. Introduction

The United States Department of Commerce, Economics and Statistics Administration in its July 2011 report stated that science, technology, engineering, and mathematics (STEM) occupations are projected to grow by 17.0 percent between 2008 and 2018, compared to 9.8 percent growth for non-STEM occupations [1]. Additionally, STEM workers command higher wages, earning 26 percent more than their non-STEM counterparts and for women who hold STEM jobs; they earn 33 percent more than women in other occupations. Moreover, STEM degree holders enjoy higher salaries, regardless of whether they are working in STEM or not [1]. These statistics provide an impetus for more students to choose STEM areas as fields of study. However, the number of students choosing STEM disciplines, inclusive of computer science is not growing at the rate necessary to keep up with job demand.

According to The New York Times' Christopher Drew, studies note that approximately 40 percent of students who choose to pursue a STEM area either switch their major in college or do not graduate at all [2]. This statistic, as stated by Drew, is twice the combined attrition rate of all other majors [2]. A great deal of research has been conducted on the reasons as to why students choose not to study STEM. It has been suggested that societal stereotypes, environmental and cultural factors, a lack of visible role models, different interests and experiences, and academic un-preparedness are some of the reasons [3]-[6]. However, while these reasons are substantive and well-documented, more research is now being conducted on what happens to students during the first two years of college which deters them from pursuing their goals of becoming a scientist, engineer, mathematician or computer scientist.

One article posits that there has been a dramatic shift in the way in which students learn [7]. It suggests that most high school classes are small. A teacher works with about 30 students at a time rather than the 200 students a college professor teaches during each session. Consequently, many professors cannot offer individual attention to all students enrolled in the course, sometimes leaving some students to teach themselves, which they have not learned how to do [8]. Therefore, a continuously studied issue in higher education is teaching pedagogy and how to best offer course content to a larger population of students who has different learning styles and needs, especially found in the STEM areas.

In the report entitled Distance Education at Degree Granting Postsecondary Institutions 2000-2001, from the National Center on Education Statistics, it was noted that during the 2000-2001 academic year, 56 percent (2,320) of all 2-year and 4-year Title IV-eligible, degree-granting institutions offered distance education courses. Moreover, there were an estimated 3,077,000 enrollments in all distance education courses offered by 2-year and 4-year institutions during the 2000-2001 academic year [9]. Since that report, it has been noted that online course enrollment in the United States hit an all-time high in 2010 with more than 6.1 million students and according to the report from the Babson Survey Group, this number surpassed itself in 2011 and will only increase [10]. The report also stated that approximately thirty-one percent of higher education

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students now take at least one course online and that academic leaders believe that students are satisfied with this type of content delivery method [10].

However, there remains a question concerning online instruction and its effectiveness as compared to face-to-face instruction. Researchers have found that while some online courses have reported significant improvements in student performance over their face-to-face counterparts, other courses found no significant improvement and sometimes students performed worse [11]. Researchers also reported that the reason some online courses are unsuccessful in improving student performance is because they lack the face-to-face interaction that students desire with their instructor and classmates [12], [13]. Consequently, an alternative to online instruction is blended teaching or hybrid courses.

Hybrid courses are often seen as a third alternative in instruction delivery because they offer a mix between online courses and traditional face-to-face instruction. Some researchers describe hybrid courses as a course where 24% to 75% of the course content is delivered online and the other is face-to-face; or the use of a system that relies on computer-mediated instruction; or even a combination of web-based learning delivered using a Learning Management System, face-to-face meetings and chats or blogs [14],[15]. However, no matter what definition is used, hybrid teaching is becoming increasingly popular with many educators because not only do they view it as an effective method for reaching students whose way of learning has shifted away from more traditional techniques but also as a way to promote more active learning among a large student base.

The following section begins by providing an introduction to the environment in which the hybrid course will be offered. The next section introduces the face-to-face course which provides the foundation for the hybrid course. The subsequent section presents the hybrid course. The way that the course will be evaluated is also presented and future work is offered in the last section.

II. COURSE ENVIRONMENT

The hybrid course is designed to be offered at Georgia Perimeter College (GPC), a state college part of the University System of Georgia (USG). The University System is composed of 35 higher education institutions including 4 research universities, 2 regional universities, 13 comprehensive universities, 14 state colleges, 2 two-year colleges and the Skidaway Institute of Oceanography. GPC, a 2-year institution, offers Associate degrees in Arts, Sciences, and Applied Sciences [16]. GPC typically hosts the largest freshman and sophomore enrollments in Georgia, making it the top producer of transfer students to 4-year institutions within the state of Georgia. It has five campus locations throughout the Atlanta-metro area and services approximately 22,000 students. The number of students choosing one of the STEM disciplines is roughly 10% [17].

A. Instructional Methods of Delivery

GPC offers courses through several modes of delivery which include face-to-face, online and hybrid. While the number of online course offerings and students enrolled in online courses has grown significantly, there still remains a need for hybrid course offerings in certain areas. The STEM areas typically have less hybrid courses than their humanities counterparts, yet all students are required to take at least College Algebra with a large population required to take Chemistry I and one computer science course. A survey of the 95 hybrid classes offered during the 2011-2012 academic year found that there were approximately eight hybrid classes offered in science and mathematics and none offered in computer science or engineering. Furthermore, of the eight science and mathematics hybrid classes offered, only the statistics course offered is accepted as credit toward a STEM degree; the other courses offered are general science courses. An additional survey of hybrid courses was conducted for the fall 2012 semester. The results again revealed that basic science and mathematics courses were offered, one upper-level division computer science course offered and again no hybrid course offered in engineering.

B. Hybrid Courses at GPC

Hybrid courses are offered in five instructional delivery modes at GPC. These modes include:

1) *Type A* - face-to-face meeting once per week
2) *Type B*- face-to-face meeting on alternate weeks
3) *Type C* - face-to-face meeting on alternate Saturdays
4) *Type D* – fact-to-face meeting on four Saturdays in which classes meet for a double class period
5) *Type E* – face-to-face meeting on Super Saturdays, in which classes meet for a triple class period for two or three Saturdays.

The other instruction is offered online. It should be noted that students are informed that hybrid courses do not offer a reduced workload, but offer the flexibility of online learning with personal contact with the instructor and classmates. All hybrid course students complete the same amount of course work with the same learning goals and outcomes as their traditional face-to-face or online course counterparts [18]. The classes are held during a 16 week semester.

The author has taught traditional face-to-face courses at the undergraduate level within the computer science curriculum for many years. Prior to the design of the hybrid course, the author taught *CSCI 1300 – Introduction to Computer Science* using the traditional face-to-face method of delivery. At GPC, *CSCI 1300* is a course that is part of the common core and therefore it is a commonly taught course. The next section describes the course; the student population enrolled; and, includes the methodology the author used to teach the course. This material is used as the basis for the design of the hybrid course which is presented in the subsequent section.

III. Introduction to Computer Science

A. Course Description

CSCI 1300 – Introduction to Computer Science is designed to provide students with an overview of selected major areas of current computing technology, organization and use. Topics surveyed include the history of computing, data representation and storage, hardware and software organization, communication technologies, ethical and social issues, and fundamental problem solving and programming skills [19].

Prerequisites are exit or exemption from all Learning Support, English as a Second Language (ESL) requirement and successful completion of College Algebra [19]. For computer science majors, the course is a prerequisite for successive courses within the program of study. For non-math based majors, the course meets the requirements of the common core in the area of science, mathematics and technology from which students must choose.

B. Topics Covered

Since the course is a commonly taught course, all students regardless of delivery mode are presented with the following topics [19]:

- The history and vocabulary of computers
- Problem-solving, algorithms and algorithm efficiency
- Data representation and storage
- Computer hardware and software concepts
- Computer networks
- Information security
- Programming concepts and problem-solving
- Social and ethical issues

C. Learning Outcomes

The learning outcomes are designed by the course curriculum committee. It was decided that by the end of the course, a student should be able to [19]:

- Discuss the history of computing.
- State the methods by which data is represented and stored in a computer's memory.
- Recognize and understand the fundamental hardware components of a computer system.
- Recognize and understand the fundamental software components.
- Understand the concepts of current communication technologies.
- Understand basic networking and information security.
- Recognize and understand social and ethical issues involved in computer use.
- Analyze a basic real world problem and solve it with a computer program.
- Understand and write algorithms using fundamental computing concepts.

D. Student Population

The course is designed for and utilized by students who have chosen one of the STEM areas as a major. Non-STEM majors are encouraged to enroll in another course, with similar content but designed specifically for students not pursuing one of the STEM areas as a major. However, since *CSCI 1300* can also be used by non-STEM majors to satisfy a math requirement, the student population is often varied. On average, course enrollment is between 20 and 30 students, with the percentage of STEM to non-STEM majors fluctuating.

The next part of this section describes popular teaching styles and introduces collaborative learning. Also presented is the rationale for the utilization of the stated teaching style.

E. Teaching Methodology

According to Grasha, there are four approaches to teaching [20]:

- Formal authority, an instructor-centered approach where the instructor provides the flow of content
- Demonstrator/personal model, an instructor-centered approach where the instructor demonstrates the skills
- Facilitator, a student-centered approach where the instructor acts as a facilitator and the responsibility is placed on the student to achieve results
- Delegator, a student-centered approach where the instructor delegates and places the responsibility for learning on students and/or groups of students

The instructor decided that based on the student population enrolled in the course, that formal authority would be used as the teaching style. It is noted that this teaching approach has its challenges, with one being the lack of personal engagement between teacher and student; and student and student. Consequently, the instructor also incorporated collaborative learning into the course.

F. Collaborative Learning

In educational environments, student study groups are often formed to gain better insight on course topics through collaborative efforts. Collaborative learning is defined as the grouping and/or pairing of students for the purpose of achieving an academic goal [21]. Davis reported that regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer, than when the same content is presented in other more traditional instructional formats [22].

Supporters of collaborative learning suggest that the shared learning environment allows students to engage in discussion, take responsibility for their own learning, hence becoming critical thinkers [21]. Research has shown that collaborative learning encourages the use of high-level cognitive strategies, critical thinking, and positive attitudes

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toward learning [23]. Further, it has been suggested that collaborative learning has a positive influence on student academic performance [24].

G. Content Delivery

The class time was divided into three segments. The first half of the class time was spent providing students with the theoretical concepts, while the second part of the class period students spent solving problems independently or in groups. Toward the end of the class period, students shared the results of the work and concepts were summarized and reinforced. The instructor found that this method worked well for both STEM majors, who needed both the theoretical foundation and the application; and, for the non-STEM majors who enjoyed the application of the course content. Consequently, the instructor decided to use this model as the premise for the development of the hybrid course.

IV. Hybrid Course Design

As previously stated, a survey of courses found that during the academic year 2011-2012, no hybrid courses were offered in computer science. A survey of the fall 2012 classes, found that once hybrid computer science course was offered, but it was for computer science majors only and is typically taken by second year students who are on the verge of transferring to a 4-year institution the next semester. Therefore, the uniqueness of this design is for a course offered at the freshman level which will impact a larger student population with a wide variety of technical backgrounds.

A. Course Content and Learning Outcomes

Since the course is a common course, the learning outcomes and the course content remains the same. However, it was decided that during the first face-to-face meeting an overview of the Colleges' Learning Management System, iCollege/Desire2Learn, would be done to ensure that students know how to properly use the system since the course would rely heavily on its use.

B. Teaching Pedagogy

It was decided that the facilitator teaching style would be utilized. The facilitator teaching method, unlike formal authority, is a more student-centered approach which shifts the focus of activity from the teacher to the learners. This method includes active learning, collaborative learning and inductive teaching and learning [20]. The facilitator teaching style has been stated to work best for students who are comfortable with independent learning and who can actively participate and collaborate with other students [25]. In particular, this approach was chosen because in education literature, the method has been shown to increase students' motivation to learn, to lead to a greater retention of knowledge, and to positively impact attitudes toward the subject material being taught [24], [26], [27]. Moreover, the method places a strong emphasis on collaborative learning. Additionally, the author had previously used this method in similar courses and has had good results [28].

C. Content Delivery

As previously stated, researchers note that there has been a dramatic shift in the way in which students learn [7]. Technology supported learning provides students with an opportunity to view online situations and examples that help to aid the learning process. Additionally, technology supported learning has been shown to be beneficial to students who are visual learners rather than auditory learning [29]. It has been noted that students process visual information 600,000 times faster than text, and visual aids can improve learning by 400% [30]. However, from a delivery perspective, technology supported learning provides a semi-permanent resource which allows students to re-visit the clips, thereby having the potential to develop greater understanding of the material.

Consequently, it was decided that the PowerPoint slides that the author typically uses in face-to-face classes, would be revised to include an enhanced learning experience for students. The slides would be revised using Camtasia Studio. Camtasia is a screen recording and video editing tool that allows educators to edit and share high-quality screen video on the Web, YouTube, DVD, CD, portable media players and the iPod [31]. The slides would be posted in iCollege. iCollege also has chat, blogs, video and email features.

D. Course Organization

The instructional delivery format that the *CSCI 1300* hybrid course will utilize is Type A, which means that the face-to face class period will meet once per week for 1 hour and 15 minutes and all other meetings will take place online.

Prior to the class meeting, students will be strongly encouraged to view the enhanced PowerPoint lecture slides available in iCollege/Desire2Learn. At the end of each lecture, end-of-lecture questions will be asked to which students will receive immediate feedback. The instructor will also have access to student responses and performance. This information will be used to determine the content and the time frame needed for review of material during the face-to-face class period.

The face-to-face class period will be spent as an interactive lab environment coupled with collaborative learning, much like those seen in flipped classroom models [32],[33]. For the first 15 minutes of the course, the instructor will answer questions and review key concepts from the online lectures. The next 45 minutes will be spent by students engaged in hands-on laboratory work using the computer. The last 15 minutes will be used to summarize the concepts presented and to briefly introduce the next concepts to be discussed. Figure 1 presents the design for the face-to-face class meeting.

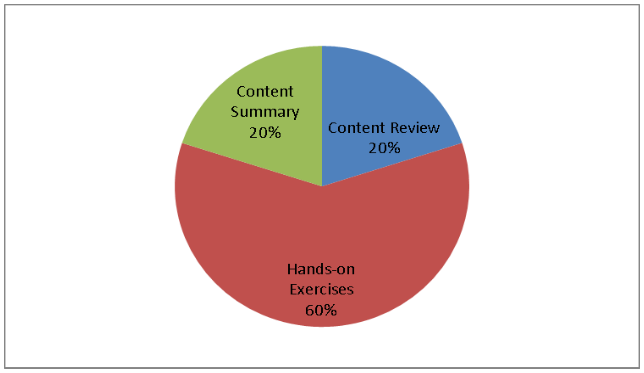

Figure 1. Hybrid Course Design

To teach hardware and operating system concepts, computer simulators will be used like those from teach-sim educational simulators and Cisco Binary Game [34], [35]. To teach problem-solving, algorithm writing and efficiency, students will utilize the algorithmic simulators that accompany the required laboratory textbook. Visual Studio is used as the development environment and students will use this to program small-scaled projects in C++. Lastly, to engage students in the concepts of social and ethical issues, it was decided to use case studies and debates. Students will be divided into teams and given an issue in which they must debate the pros and cons of the argument. Table 1 provides an overview of how topics will be covered during the 16 week semester.

TABLE I. CONTENT DELIVERY

Week	Topic	Activity
1	Introduction to Course and History of Computing	iCollege review
2	Representing Algorithms	Algorithmic simulators
3	Attributes of Algorithms	
4	Binary Numbering System	Cisco Binary Game and binary numbering simulators
5	*In class exam*	
6	Boolean logic and gates	Logic gate simulators
7	Components of a computer system	Computer simulators
8		
9	Basic networking	Network software simulator
10	Software security	Research on threats and encryption software simulators
11	*In class exam*	
12	Introduction to C++	Introduction to and using Visual Studio
14	Ethical issues	In class debates
15		
16	Prepare for final exam	

V. ASSESSMENT

A. Student Assessment

Students will be assessed in the following manner:

- *End-of-lecture questions* – these questions are basically designed for student use and will be used by the instructor not as a tool for grading but to determine concepts on which the instructor needs to spend more time reviewing during the class period.
- *Assignments* – the common course outline requires that there be a minimum of eight projects completed during the semester
- *Exams* – there will be two in-class exams
- *Final exam* – one final examination will be given at the designated time at the end of the semester

B. Course Assessment

Two types of assessments will be utilized to determine the effectiveness of the course. The first assessment will be a student survey which will include measures on students' attitudes and self-efficacy as it relates to course material and content delivery. The second evaluation will be student performance.

VI. CONCLUDING THOUGHTS

The aim of this paper was to present the design for a hybrid breadth-first introductory course in computer science taught at a 2-year institution. The course content, learning outcomes, teaching pedagogy, course organization and how the course will be evaluated were presented. Future work includes the redesign of the traditional PowerPoint slides to include an enhanced learning experience for utilization in the hybrid course.

The course is unique in that it provides an opportunity for a large number of students whose technical skill set is often varied to engage in and actively learn foundation principals in computer science. The delivery of the content through hybrid learning provides a blended mix of the traditional face-to-face interaction students often desire with the flexibility of online learning, which many 2-year institution students need. However, the author acknowledges that the redesign is not without its challenges. The author anticipates concerns in the areas of student perception and performance. Moreover, the author has some concerns on creating the videos to ensure that the theoretical concepts are correctly captured for the skill set of the audience.

It is projected that the U.S. will see over 1.2 million STEM job positions open up by 2018. As the workplace and the way in which students learn change, the way in which to best meet the needs of these constituency groups must change as well. As educators it is our job to ensure that our students are ready for these and other opportunities and to provide them with an educational experience that will increase their chance for success.

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