Flipping the Classroom by Using Cloud Services and Third Party Online Courses in Traditional Class Settings Enables All Computer Science Students an Equal Education

D. Powell[1] **and J. Hollingsworth**[1]
[1]Department of Computing Sciences, Elon University, Elon, NC, USA

Abstract - *Massive Open Online Courses (MOOCs) and other online educational courses combined with free cloud platform as a service (PAAS) offerings provides a perfect environment for universities, large and small, public and private, to provide an equivalent state of the art undergraduate education to students. Traditional classroom classes can flip the classroom and have students review online content assignments outside of class and use class time for class discussion, assessment and team problem solving exercises. Elon University flipped the classroom for an Enterprise Programming Course during the spring 2014 semester using free and low-cost course online content material from codeschool.com and udemy.com with free cloud computing services from CloudBees. The flipped course was successful and will be tried at Elon in the fall with three different courses. This paper presents the advantages, disadvantages and challenges in using online resources and cloud computing as well as a discussion of lessons learned.*

Keywords: Cloud computing, Online courses, Flipping the classroom, Enterprise programming

1 Introduction

Graduating undergraduate computer science students need to understand mobile computing, desktop computing, enterprise computing and how to learn in a constantly changing world. Technology is rapidly changing and computer science faculty are highly challenged to offer the best and latest information in their undergraduate courses. University budgets are shrinking while costs of software, hardware and system administration are increasing. Despite the shrinking budgets and the rapid pace of change, the great news is that free cloud computing and free or low-cost online courses provides Computer Science faculty at all universities, public and private, large and small, the opportunity to offer their undergraduate majors a "Best in Class" education by flipping the classroom. The flipped classroom also known as flipped learning [1] inverts traditional teaching methods, delivering instruction online outside of class and moving class exercises and discussions into the classroom.

We believe that flipping the classroom by leveraging of online resources and the use of cloud computing is replicable across many of the standard computer science curriculum courses described in the Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science [2].

This hypothesis was proven at Elon University during the spring 2014 semester when we flipped the classroom and offered a class on enterprise programming. This paper describes the availability and use of online resources to provide content and the availability and use of cloud computing to provide the software and hardware for programming exercises and projects. This paper will present the advantages, disadvantages and instructor challenges in using online resources and cloud computing. The paper concludes with a discussion of lessons learned from flipping the classroom and future directions.

2 Online Courses

Most undergraduate computer science curriculums have similar courses based on the ACM Computer Science 2013 Curricula Guidelines, ABET 2013-2014 Criteria for Accrediting Computing Programs [3] and needs of their constituents. Typically, two of the expected program outcomes of a CS program are to provide students the skills for a lifetime of learning and to be successful in the field after graduation.

Many online resources are available from universities and from private companies that directly map or partially map to undergraduate core courses or elective courses. These online resources are available in the form of Massive Open Online Courses (MOOCs) from organizations and universities such as Coursera, Udacity, UC Berkeley and MIT [4] to high quality instructional videos from Udemy.com, Lynda.com, CodeSchool.com and Youtube.com. The challenge to the instructor is to find the online course or courses that have the materials that best match the content and instructional level for their class.

At Elon, a senior level, elective course on Enterprise Programming is offered every two years. The content of the course is focused on learning the latest technologies, best practices and best development techniques for designing and implementing a medium size enterprise application. Discussions with alumni indicated that the Java Spring Framework was the leading Java Framework in the enterprise field and would expose the Elon students to key concepts of Aspect Oriented Programming, Dependency Injection, Object Relational Mapping and Security. The department did not have any experience teaching the Java Spring Framework but wanted to offer the students the course. The authors searched for online courses and materials that they could quickly learn from experts in the field and in turn provide content for their traditional, face to face, twice a week class meetings for a fourteen-week semester. The authors found two online course providers and four courses from these providers to provide course content. The providers were codeschool.com and udemy.com. Two of the four courses, "Try JQuery" and "Discover DevTools", were from codeschool.com and two of the courses, "Servlets and JSPs: Creating Web Applications With Java" and "Java Spring 3.2 Framework" were from Udemy.com.

Selected online video course content was assigned as material to be completed before each class. Elon still had the traditional class, face to face 100 minute meetings twice a week. However, the class time was used for material highlighting, class discussion, and assessments instead of lecture. Elon found that the use of online video course content for a traditional course had many advantages, some disadvantages and some instructional challenges.

2.1 Online Course Advantages

The use of online course content has many advantages over traditional textbook driven classroom learning. Some of these advantages are the experience of the instructor, the high quality of the content, 24x7 availability, dashboard monitoring tools and low cost. An experienced, senior software developer and user of the technology on many successful and unsuccessful applications created the video content. The instructor can clearly identify best design and development practices. In Elon's case, the faculty member scheduled to teach the class had no previous experience with the Java Spring Framework. The video content developed by a software engineer with 14 years' experience allowed the Elon instructor to gain experience while providing expert content in a first time offered course to the students.

The selection of the video online content by the instructor was aided and enhanced via online reviews. The video online content had been vetted by previous students of the online course who had provided a rating of 1 to 5 stars along with comments on how well they liked the course. This rating system provided assurance of the quality and applicability of the course. In the case of the two Udemy courses used at Elon, the nine hour, Servlets and JSP course had a 5 star out of 5 star rating and had been taken by 6,300 students with 93 providing detailed review comments. The 27 hour, Java Spring Framework course had a 5 star out of 5 star rating and had been taken by 4,100 students with 92 supplying review comments.

The video online courses from major vendors are of high quality. They have been well designed, rehearsed and edited. The videos use voice, color, animation and live demonstrations to a degree that enhances learning and are in general superior to the typical university course taught by a faculty member using PowerPoint and live demonstrations.

The video online courses are available 24x7. They can be played from anyplace and at any time. Most of these courses have mobile applications so the course materials can be downloaded and played offline. From a learning perspective, students have the ability to stop, rewind and replay sections that they did not completely understand. The replay ability is also beneficial for students to catch up on missed classes due to an interview, illness or weather cancellations.

Most video online courses have a dashboard that monitors student progress. Faculty can monitor the individual student progress to identify students that are having issues or falling behind. Students can also interact with each other within or outside the university via online forums and wikis to ask questions, discuss programming issues or add additional insights. For example, codeschool.com has a dashboard that displays the course completion status of the logged in user for each course. The completion status shows the percentage of the course completed by the user. Completion consists of watching the video instruction and then successfully coding solutions to interactive programming challenges. Students were required to individually show at the start of designated face-to-face class meetings the completion status of "Try JQuery" and "Discover DevTools". The two Udemy courses also had a dashboard that showed the completion status of each lecture. The Servlets and JSP course had 7 main Sections made up of 60 video lectures and the Spring Framework had 16 main Sections made up of 169 video lectures. Typically, one section (consisting of two hours of video content) was assigned for completion, before each class session.

The cost of most online courses is very cheap compared to the purchase of textbook(s). In the case of codeschool.com, there is a monthly membership charge of approximately twenty dollars for access to all of their courses and some courses are completely free. The two courses used at Elon, "Try JQuery" and "Discover DevTools", were completely free. In the case of Udemy.com, the cost of the course is dependent on the instructor. At Elon, we contacted the instructor, and got a special rate of ten dollars a course.

2.2   Online Course Disadvantages

There were only two disadvantages to using online content. The first disadvantage is that students have traditionally learned from textbooks. The student is comfortable with coming to class for a lecture on a chapter, then reading the chapter, highlighting key points and completing end of chapter exercises.   The online courses require more motivation and engagement on the part of the student to complete the online video "lectures" and to come to class prepared with questions. The superbly done video lectures are not repeated during class time but rather the class time is focused on meaningful discussion and assessment.

The second disadvantage is that a textbook is easier to reference than an online video course. Students need to learn to keep notes with appropriate reference hyperlinks during a video course to better review for a weekly quiz or monthly exam.

2.3   Instructor Challenges

The role of the instructor changes from one of primarily delivering lectures to one of organization and assessment. The key challenges are finding the right online course materials, finding and validating the supporting software, developing the syllabus and student motivation.

There are many online courses available and many coming out daily. The instructor is challenged to find and review the online course(s) materials that enhance the course content that have been vetted by the community. In some cases, there may be a single course that completely meets the course objective. However, in many cases, there may be multiple online courses that supply pieces that can be selectively chosen and woven into a better course.

The instructor needs to review or identify the course software packages, version numbers and code differences if any to be used to support the online course. Software changes rapidly and videos can quickly fall behind vendor releases of major new versions. The software used in class must match as close as possible the software used in the online content.

With respect to the Enterprise programming course at Elon, the key challenges to finding online content fell into deciding on a consistent Interactive Development Environment (IDE), test application server, MySQL development interface and client browser for all online content. Most online courses either use an IDE of Eclipse or NetBeans. The test application servers are usually Tomcat or Glassfish. The MySQL development environment is either phpMyAdmin or MySql Workbench. The browser and debugging tool is either Firefox with Firebug or Chrome with DevTools. Elon chose online content that matched the Udemy.com selected videos. The selected software was the Eclipse IDE, the Tomcat application server, MySQL Workbench and the Chrome browser with DevTools.

The instructor needs to develop the course syllabi for each semester class with due dates for viewing and completing selective online course content. The instructor needs to identify additional course material to supplement online course content. The instructor needs to develop assessment materials that include quizzes, class exercises, large projects and exams. For the Elon course, the seven quizzes, midterm exam and final exam were developed from industry sample certification exams for Oracle Java EE 6 Web Component Developer Certified Exam and SpringSource Web Application Developer. The certification tests were selected to provide external validation for the course coverage and learning of our students. The large number of video hours to complete the Udemy course required a decision to be made on whether to complete all lectures and get a Udemy "Certificate of Completion" or to stop at an earlier point to allow time for a semester project. Ideally both could have been done but, due to time constraints, a choice was made to complete all lectures   and receive the completion certificate.

Finally and most importantly, the instructor needs to provide the motivation for each class to keep the student on track. The student is exposed to a different style of learning compared to in-class lectures. The class session is used to continually assess the student progress and understanding of the material and to provide team development exercises. To keep the student engaged, the student was required to demonstrate the working completion and deployment to the cloud of the software covered in the previous class assigned video materials. For the video materials assigned for the current class, the student had to show the course dashboard completion status.

3   Cloud Computing

Cloud computing offers Platform As A Service (PAAS) functionality for software deployment. Over the past three years, Elon has successfully used free cloud computing from Google App Engine, IBM Smart Cloud Enterprise and CloudBees to support classes on web development, mobile android device development and enterprise programming [5][6][7]. The most recent course on Enterprise programming used CloudBees as the cloud provider. Cloud computing offers many advantages and few disadvantages.

3.1   Cloud Computing Advantages

Cloud computing offers all universities a chance to provide free access and deployment using the latest software and hardware. Universities are no longer constrained based on budget or in house administrative support. The advantages are:

1. There is no cost for the hardware and software. Each student can register for a free account that comes with a free quota of file storage, database storage, application programming interface calls (API) and

emails sent. The quotas are generous and have never proven to be a constraint.

2. The hardware and software is available 24x7. It is administered by the cloud vendor with frequent updates and patches. The cloud vendor provides extensive documentation and examples of how to use the cloud. Each cloud vendor is used by thousands of developers. As such, the cloud is very reliable and dependable for course instruction. In the past three years, the Elon student has not lost any time due to the Cloud vendor not being available for deployment.

3. There are no internal firewall issues for code deployment. The student can deploy code from school, from home or from anywhere with an internet connection. The student can easily demonstrate developed web applications or web services to employers.

4. With Google App Engine and CloudBees each student signs up for their own account. Each student account has its own security and sandbox. The source code development and work of one student is not visible or accessible to another. This helps to prevent the unauthorized sharing of code among students. The account will stay with the user after the course and after graduation. This allows students to create a portfolio of projects from different courses to show employers during interviews. Unfortunately, the IBM Smart Cloud Enterprise had individual student accounts that only lived for the duration of the course. This proved to be a problem for students that wanted to demonstrate their projects at job interviews after the semester completed.

5. Each of the three listed cloud vendors provides support for Java Enterprise standards for servlets, java server pages and access to a back end data store. However, if MySQL is used as the back end database on Google App Engine then there is a minimal cost for storage.

3.2 Cloud Computing Disadvantages

Each of three PAAS offerings has proven very reliable for students and faculty. However, there is one large disadvantage of using a commercial offering and one small disadvantage.

The large disadvantage is the dependence of the course success and student success on the cloud platform being freely available. If the company stops offering the cloud service or changes the costing structure and eliminates free usage in a middle of a semester then this would be disastrous to the course. On the positive side, the Google App Engine cloud has been around for over three years and the free cost

structure has not changed. The IBM Smart Cloud was available for two years and then IBM announced they would no longer support it as of Feb 2014 and would replace it with a new offering called BlueMix. This new offering is currently in Beta and will be available in 2015. IBM did notify all impacted universities four months in advance so no in session fall courses were directly impacted. However, faculty teaching in the spring had to find a new cloud provider. In the case of Elon, we chose CloudBees and have been very impressed. It is our planned platform of choice for fall 2014 offerings. CloudBees fully supports the Java Enterprise 7 standards and provides free access to Tomcat, Glassfish, JBoss and Wildfly application servers. In addition, it provides free access to a MySQL database and free access to a mail server for sending email.

The one small disadvantage is a vendor specific implementation often has limitations on the Java Enterprise Standards implementation. We ran into this limitation with respect to the Google App Engine which supports most of but not all of Java Enterprise Edition 7. Servlets and Java Server Pages are directly supported but Java Server Faces is not. Other APIs that are not fully supported are File IO and JPA.

3.3 Instructor Challenges

The main challenges in selecting a cloud service provider is to identify one that is widely used, well documented, free, supports Java Enterprise 7 and provides access to JavaMail and an external SQL database. Once a provider is selected then there is a significant time commitment invested by the faculty member to understand the vendor specific code deployment configurations required by the vendor.

4 Conclusions

The large number of free or low cost online course content and free use of cloud PAAS computing running industry standard Java Enterprise Edition software provides every university access to the very best instruction and computing. The challenge to faculty is to identify the best content and to flip the classroom to have students watching and interacting with online course content outside of class. Instead of delivering lectures, faculty will spend class time focusing on question and answer sessions, group exercises and assessment. Faculty have dashboard and monitoring tools to best identify the students that need more attention and provide them additional feedback.

At the end of the Elon spring semester, the twelve students in Enterprise Programming were anonymously surveyed for their thoughts on our experiment with flipping the classroom. Nine of the twelve students (75%) enjoyed the format of flipping the course from the standard class lecture, two of the students (16.6%) were not sure if they preferred it and one student (8.3%) preferred the traditional lecture format. However, seven of the twelve students (58%) indicated they

would have preferred more in class problem solving exercises and an end of course project to pull all the concepts together. Students suggested that the in class exercises could be extensions to the work done in the previewed online videos or a completely different problem solving exercise to reinforce the topics covered in the videos. The authors completely agree with the student suggestions that more problem solving class exercises and a culminating project would have been beneficial. The authors made a tradeoff to cover more material at the expense of fewer exercises and in hindsight should have compromised on the amount of material covered and included more exercises.

Based on the lessons learned in flipping this prototype class, three core classes in the fall 2014 will be partially flipped with a percentage of the classes in each course flipped and a percentage kept in the traditional format. The percentages will be based on an analysis of the online materials available and how well they match the course objectives. These core classes will be for Computer Science II, Computer Science III and the Computer Science Capstone. Second year, Computer Science II students learn object oriented java programming on a desktop. Third year, Computer Science III students learn basic web programming with HTML, CSS, javascript, servlets, java server faces and connecting to a back end, SQL database. Fourth year, Computer Science Capstone students learn design patterns for mobile, desktop and enterprise applications.

In closing, the authors believe the use of the latest professionally developed online content combined with cloud computing and in class exercises and assessment will allow Elon to offer courses that are as good as any university with any budget anywhere in the world. This practice can be replicated at any other large or small university.

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