

**Higher Education Online:  
A Comparative Analysis of Online Programs for  
Free University-Level Education**

by

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Submitted to the Department of Electrical Engineering and Computer  
Science

in partial fulfillment of the requirements for the degree of

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**Abstract**

The advent of online education programs has made university-level course material available to anyone with an internet connection. Top universities across the United States have begun offering online versions of their premier courses for free. Simply offering these courses is not enough to fully support free online education, however. In order to match more traditional, offline teaching methods, the online teaching field will need rapid iteration. To move forward with this iteration process, universities developing online courses need to first evaluate the effectiveness of their current programs. This thesis provides one evaluation perspective, using six heuristic categories (presentation style, presentation size, grading & evaluation, goals & rewards, staff support, and community) to evaluate three high-caliber, online, university-level programs (Coursera, edX, and Udacity). This thesis also offers insights into how to improve upon these programs to better meet the needs of students seeking higher education online.

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# Chapter 1

## Introduction

To aid life, leaving it free, however, to unfold itself, that is the basic task of the educator. –Maria Montessori

### 1.1 Objective

Recent years have seen a vast increase in online education programs. These programs range in scope and target audience, but all have attempted to make the education process accessible to more students in more locations. In the year of 2012, universities have finally begun to truly take on the project of providing free, online education. Unlike the earlier efforts of MIT's OpenCourseWare and Stanford's Openclassroom, universities are now attempting to release massive, synchronous online courses for students to complete. With such overwhelming investment and effort being put into these projects, the online education programs are questioning how to make the courses as effective and supportive of the students as possible. This will in turn support the future success of the programs. Without adequate support and structure, these programs run the risk of failing their students and ultimately failing their investors.

As both a teaching assistant and a student in university-level education over the past six years, the education process is a topic that deeply interests me. In order to contribute to the evolution of online education, I have performed a comparative analysis of three of the largest online university-level education programs released

this year. I have examined courses from Coursera [1], edX [4], and Udacity [8]. These programs each offer a form of massive, online courses for students to take. I have examined these programs with the objective of identifying what practices will help the programs succeed, and what practices could to be improved to reach that success. I have established six characteristics with which to analyze these programs: Presentation Style, Presentation Size, Grading and Evaluation, Goals and Rewards, Instructor Involvement, and Community. These six characteristics, while broad, allow for identification of which practices are potential weaknesses within an education program, as well as exposing which part of the students' education is jeopardized by the weakness.

Evaluating these courses accurately takes in-depth research both into current educational research as well as the process and approach of each of the education programs. The courses of each program require careful consideration, acknowledging both what brings strength to the program as well as those practices that might make the courses less effective. Meanwhile, the success of these online education programs will be a great stride forward for education throughout the world. With so much for students everywhere to gain from these programs, it is with great enthusiasm that I investigate Coursera, edX, and Udacity with the objective of acknowledging and supporting their educational practices.

## 1.2 Approach

In order to adequately investigate the educational programs offered by online university-level education programs, I opted to perform a comparative analysis of the current courses offered. The first step was to identify which programs were worth investigating. I examined many online education programs and confirmed that, while not the only offerings, the programs run by Coursera, edX, and Udacity offer a good representative sample of the synchronized online courses I'm interested in investigating.

The second step I took was to study the results of a selection of work in current educational research. This research was collected from a several contributors, includ-

ing the Department of Education [24], educational researchers [23], [18], [14], and educators' experiences in the classroom [11], [15]. From this research, I established a large set of qualities that have been found to either positively impact a student's long-term retention of information, or to have relatively little influence on the learning process. I divided these many qualities into six broader categories, which I refer to as characteristics of a successful classroom. A course which satisfies the qualities of all six characteristic categories will likely support a successful educational environment.

The third step was to participate in the courses offered by each of the online programs I selected. While taking all of the courses in each program would be impossible since they are so new, I participated in four current courses from the programs to acquire a representative sample of their performance. Examining each of the classes in action allowed me to evaluate how the programs were performing relative to one another, using my characteristics as guidelines. I then compiled my resulting impressions, establishing the relative strengths and weaknesses of each program.

The fourth and final step I took was reflecting on my findings. I focused on two outcomes with my reflections. First, I have provided feedback to each of the education programs I investigated. With the weaknesses identified by my comparative analysis, I aimed to provide suggestions on strengthening those weaknesses for future courses. Second, I examined how to compile the elements of these many characteristics into an improved online education program. I emphasized the key practices required to provide many of the supporting characteristics of a successful education program, as well as tactics for avoiding common pitfalls found in my comparative analysis.

All of these reflections are my own opinions, based on my experience as both a student and a teaching assistant. My opinions are informed by the educational literature I have read. My opinions do not reflect the opinions of MIT, my advisors, or any other party.

## 1.3 Highlights of Findings

Through my research, I arrived at a handful of results that are particularly important. Most importantly, each of the education programs contains both strengths and flaws. Coursera provides some great opportunities for innovating on evaluation, but needs more engaging presentation options. EdX has the strong foundations for community, but lacks in providing evaluation and long-term goals. Udacity has an excellent presentation style, but struggles with supporting a long-term community. These diverse results mean that each program definitely has the potential to be an excellent education tool for students. At the same time, the weaknesses I found indicate that the work to provide quality online education programs is still far from complete.

Additionally, I have found that there is still a great need for incorporating more active learning opportunities into online education programs. Interacting with the instructors through questions or comments during the video lectures is not an option in any of the courses I examined. There were also no group assignments in which students could interact together with the course material. The value of learning in groups has been identified as one of the best ways to improve student performance and long-term retention for offline courses [23]. Providing different formats through which students can engage in the material is valuable; bringing these different formats into online courses might be a great next step for online education. While each program I investigated had different strengths, the few active learning opportunities leaves a little more room for improvement.

## 1.4 Thesis Roadmap

This thesis is divided into seven chapters. This first chapter identifies the key objective, approach, and highlights of my findings. The second chapter examines the high-level structure of each of the online educational programs I investigated, with particular focus on the differentiating characteristics of each program. The third chapter provides detail on each of the characteristics I employed for evaluating the



online programs, drawn directly from the current results in educational research. The fourth chapter contains my reflections on the structure and design of each of the four classes I examined in detail; I again keep my focus to a high level, identifying the key features and design decisions behind each course. The fifth chapter details the results of my analysis: I evaluated the relative strength of each of the courses in each of the characteristics I defined. The sixth chapter contains my suggestions for improvement, as well as my insights on constructing the ideal educational program. The seventh chapter explains both the future work that should be done to bring online education to the next level of success and my contributions to that effort.



# Chapter 2

## Background on the Evaluated Programs

To get a better understanding the programs I have evaluated, I first provide some background information on each program. For each program - Coursera, edX, and Udacity - I provide information about the founding vision and structure, as well as details on some of the key design decisions that help to differentiate the programs from one another at a high level. The details of each program are captured in Table 2.1.

	Coursera	edX	Udacity
Release Date	April 18, 2012	May 2, 2012	February 20, 2012
Number of Universities	16	3	0
Number of Courses	117	7	11
Number of Disciplines	16	3	3
Certifications	Sometimes	Yes	Yes

Table 2.1: This table shows the high-level details of the three online educational programs investigated here. Udacity is the only independent program investigated; it has no university directly supporting it. Coursera's courses each decide whether or not they will provide certification, while all of the courses in edX and Udacity provide certification upon completion.

## 2.1 Coursera

Coursera is a “social entrepreneurship company” with the mission to “empower people with education that will improve their lives, the lives of their families, and the communities they live in,” [2]. To achieve this mission, Coursera launched with 117 courses from 16 different universities. Stanford University, UC San Francisco, Duke University, and Princeton University are among the many contributors. The courses offered have been arranged into 16 different disciplines, ranging from Computer Science to Biology, and from Humanities to Economics. Though launched on April 18, 2012 [13], Coursera has the largest catalog of courses available within its program as of the fall of 2012 [1].

**Flexible Structure** With 16 different universities contributing their own courses with their own personal flavor, Coursera’s course structure has a variable quality that is not found in the other programs I investigated. Rather than having each course adhere to a certain set of rules, the instructors for each course are instead able to pick and choose which features they want to implement for their course. They are free to use automatic, electronic grading systems or to employ peer-review grading systems, for instance. This flexibility allows for all of the universities to maintain some identity while working under the umbrella of a single program.

**Pedagogical Foundations** Coursera explains its educational focus through its pedagogical foundations [3]. These foundations are designed to be the baseline for constructing all of the courses that the program offers. These foundations can be broken down into four critical pillars. First, the importance of testing and forced recall to support long-term retention. Second, the power of immediate feedback and the ability to retry incorrect work, called “Mastery Learning,” [3]. Third, the benefits of allowing students to assess one another in a peer review format. Fourth and finally, the need for interactive learning opportunities in each lesson. With these foundations at the core of each course added to Coursera’s program catalog, Some familiar features emerge among the diverse course offerings. More importantly, these foundations

provide Coursera with an investigative tool to support iteration. With each course offered, they can evaluate the success of that course in terms of how it meets these four educational pillars.

## 2.2 MITx and edX

In the spring of 2012, MIT began its newest online education program, MITx. In past years, MIT has provided access to most course materials through MIT's OpenCourseWare [6]. OpenCourseWare offers the materials for over two thousand classes, but there is no instructor support or community around these materials - they are simply in an open repository. The main missing component, I believe, is the evaluation; work can be done, but cannot be checked, acknowledged, and certified. To build a more directed, integrated educational experience on the web, MIT started the MITx program. 6.002x, an introduction to circuits and electronics, was released as the pilot course. The course was very successful and well-received [22], but was only the first step in MIT's larger vision [7].

**Transition to edX** On May 2, 2012, MIT and Harvard announced their plans to provide a single, unified front into the world of online education [20]. The new program was christened edX, with the mission of "creating a new online-learning experience with online courses that reflect [the universities'] disciplinary breadth," [5]. The fall 2012 program offers seven courses from MIT, Harvard, and UC Berkeley. These courses will run alongside their offline counterpart courses at each university. The courses come primarily from Computer Science, as well as an introductory chemistry course from MITx and a Public Health course from HarvardX [4]. Even with three universities engaged in the edX program, it has the smallest set of courses offered this fall, and its courses are also the least diverse of the evaluated programs. This smaller program size is likely due to their plan to provide a unified experience across all the courses.

**A Common, Open Platform** Unlike the other programs investigated in this thesis, edX’s courses are all built with an “open-source online learning platform,” [5]. This common platform guarantees some level of consistency across the many classes being offered, much as the structure of Coursera’s program provides the same pedagogy-inspired toolkit to each course. Moreover, the open-source structure of the program allows for continuous improvement from collaborators worldwide. This provides potential for rapid iteration on many of the program’s key features, including self-paced learning, online laboratory tools, and assessment for student and instructor use. These features echo the foundational pedagogy that Coursera uses. Additionally, this structure allows anyone interested in extending free online education to get involved without necessarily being a faculty member at a recognized “X University” [5].

## 2.3 Udacity

Launched on February 20th, 2012 [21], Udacity is a somewhat different program. Udacity declares that it is a “digital university... [That seeks] to innovate, educate, and collaboratively promote education,” [9]. Udacity has no official university affiliations, unlike Coursera and edX. Instead, Udacity employs individual instructors from industry and universities to build and deploy classes on their website. This gives Udacity a much more independent, casual feel, at the cost of not having a high-caliber university attesting to the depth and rigor of the courses offered. At present, Udacity offers 11 different courses in three different disciplines. As with edX, the primary discipline is Computer Science [9].

**Vocational Design** Udacity is unique in part because of the heavy emphasis placed on the Job Placement Program. All students that complete courses on Udacity can build a virtual transcript with records of their work (which is assessed on a four-level scale, ranging from Completion to Accomplishment with Highest Honors [9]). These transcripts can be coupled with CVs from students and circulated through “over 20

high tech companies,” [9] to help place successful students in their field of interest. This novel, vocational design provides another facet of the education process on which edX and Coursera are not focused: a direct way to use the education earned online for employment opportunities.

**Independent Course Construction** Without any formal university involvement, Udacity’s courses are not online versions of courses already being taught. Each course at Udacity is designed by its instructors from the ground up, which leads to some relatively unique, specific courses. In particular, it allows for many courses to be unrestricted by a typical university schedule, with a more narrow focus and directed goal. Examples of directed goals include “How to Build a Blog,” and “Programming a Robotic Car,” [8]. Each course uses the directed goals as an application of conceptual knowledge, including Application Engineering and Artificial Intelligence for the examples above. These narrow-focus courses and the wide latitude for course completion (there are no deadlines; the classes run on ”open enrollment” [9]) set the Udacity program apart from edX and Coursera.





# Chapter 3

## Educational Characteristics

In order to evaluate the efficacy of online university-level courses, I first researched several key elements of successful classrooms. I have drawn from literature on both offline and online education programs, including the work of the Department of Education [24], researchers [18], [23], and teachers [11]. Their work represents distillations of many more research efforts. I have used their research to establish six of the many categories of educational focus. I refer to these categories as characteristics that support effective learning. I here detail some of the important steps a successful classroom takes in terms of presentation style, presentation size, grading and evaluation, goals and rewards, instructor involvement and support, and community.

### 3.1 Presentation Style

The presentation style of a classroom often gets the biggest focus in educational studies, as it is the most visible and observable characteristic of a classroom. The lecture style used, the type of homework, quizzes, and labs employed to complement the main presentations, and the flexibility of those main presentations are all critical components of a successful presentation style.

The Department of Education released a report in 2010 detailing many of the most significant elements of successful online education programs [24] The results are drawn from forty-five educational research reports, examining the effect of many

classroom practices from presentation styles to community support. The Department of Education's findings had four major consequential guidelines that relate to presentation style. First, it is far more valuable to have students work in group projects or under guidance from an instructor rather than working independently through the material. Second, the inclusion of lots of extra media is not beneficial compared to simple text formats; elaborate video lectures and quizzing programs do not support learning better than text readings and text quizzes. Third, opportunities for student interaction with the material via experiments and opportunities to reflect on what they've learned, for instance through mini-quizzes on lectures, do support retention of material. Fourth and finally, learning systems that can adapt to the needs of students are much better at supporting the education of those students [24].

The most important component of a presentation style is the direction of the presentations: either to the material, or to the test. Teaching styles that focus on preparing students for particular tests do support high scores on those tests, but do not support long-term retention of the material. The imposition of test-based education also causes a loss in many opportunities for relevant learning. Educational researcher Alfie Kohn summarized a great deal of findings on the subject, stating that "from high-quality... electives to focused discussions of current events, some of the richest learning opportunities are being squeezed out [for more focus on tests]," [19]. His particular work criticizes the practices in secondary schools, but the risk is just as great for university-level courses: losing sight of the material and important concepts in favor of getting good grades on midterms can drastically hurt learning opportunities.

With regard to the benefits for adaptable classrooms, multiple research papers have discussed at length the importance of active, adaptive classrooms [23], [10]. An educational system that focuses on providing adaptive follow-up tests and feedback yielded a full standard deviation grade increase when compared to a classroom that provided static content and tests. That is, the instructors of the adaptive classroom would change the style or pace at which they presented material to the students based on the performances seen on initial assignments, while the static classroom instructors

did not. The students of both classrooms were evaluated with the same final exams. The researchers found that while 50% of students performed at or above a certain level of achievement in the static classroom, 84% of students were performing at or above that level in the adaptive classroom [10]. These results have been mirrored in other trials, in one instance improving the performance of students to more than twice the performance of students in a static control system [23].

## 3.2 Presentation Size

While considering how to present information, it is also worth noting the duration of those presentations. The scope of offered courses needs to be designed and paced to match both the content as well as the student's attention span and motivation. Similarly, the duration of presentation components must be designed carefully, be they chapters in a textbook or video lectures.

The length of the course is an important consideration for a new course. Few guidelines exist to specify what makes for the perfect course length, but the Department of Education's research indicates that there is a strong correlation between information retention and courses lasting over one month [24]. While not a hard rule, this finding does support a guideline that courses must have sufficient breadth and depth to capture students' attention for a long time. Courses that are less than a month in duration are less likely to engage students at a proper depth, and will thus yield insufficient retention in the long run.

With regards to the length of individual presentations, the best solution is even less apparent. In all of the analysis performed by the Department of Education, they found no significant connection between the duration of presentations and the learning exhibited by the students [24]. However, access to the presentation is crucial for student motivation and adaptability. The more flexibility there is in terms of which parts of a lecture a student must sit through, the more ability he has to adapt the experience to meet his personal needs. As previously noted, adaptive presentations are invaluable to fostering long-term retention; breaking up longer units into many,

small components leads to a lot of flexibility for students. Additionally, smaller components benefit in online-specific situations by being easier to access: they are necessarily smaller files to stream or download, with less risk of interruption by lossy connections.

While not causally linked to student long-term retention, I believe that providing many, short mini-lectures or readings improves the user experience. A caveat to this belief is to watch for disruptions to continuity. This format can make some transitions and connections between presentations more difficult to emphasize, however.

### 3.3 Grading and Evaluation

How to grade and otherwise evaluate students is perhaps the most controversial element of current educational research. While the traditional system of providing only a numerical score on work has persisted for many years, this is not the best structure of feedback for students. Far better educational results are drawn from providing contextual feedback - either from an instructor or from fellow students [18], [12], [14].

Kohn explains in detail some hazards of focusing on score-oriented grading in the classroom. Grade-centric courses reduce student interest in the material. Educational researcher Butler found that chasing the grade becomes more important to students than learning the material [12]. Student creativity also suffers as students tend to avoid thinking critically about the material; such thinking doesn't generally improve their grades. Worse still, these grades-oriented students often seek the path of least resistance to achieving their desired grade - there is no motivation to strive for anything beyond an "A" once it has been reached. Educational researcher Anderman found that, in worst case scenarios, this leads students to rely on cheating: earning the grade becomes more important than how it is earned [14]. With these and many other problems found in traditional grading systems, an alternative evaluation structure will greatly benefit online education programs [18].

The primary alternative in terms of evaluating students is to provide structured, constructive feedback to students on completed assignments in place of standard

number or letter grades. While the process has met with initial resistance, Kohn found that “as the days went by, fewer and fewer students felt the need to ask... about grades,” [18]. He goes on to state that “teachers who were more willing to give up control, more committed to helping students participate in assessment... are able to minimize the harm of [traditional] grading,” [18].

While the teachers Kohn worked with were restrained by the schools in which they taught, the online education programs investigated here have no such restrictions. This is a novel opportunity to have an evaluation system that promotes student learning and growth, rather than stifling it. Indeed, professor Ralph Robinson’s Calibrated Peer Review system [25] has already been shown to effectively involve students in the review process; removing the need to provide numeric scores would be the next step in improving the system.

### 3.4 Goals and Rewards

Almost as misunderstood as grades, the role that rewards actually play in the classroom differs drastically from general expectations. Hollow praise of the form “good job!” has many detrimental side-effects, and the earlier section on Grading touches on the risks of grades as the primary motivator in the classroom. Meanwhile, providing support and encouragement, as well as guiding successful students to deeper levels of thought will yield drastically better long-term retention and motivation.

Just as Kohn established the risks of over-emphasizing grades, he also details the manifold problems with providing praise for students when they perform well. The biggest risk for praise at higher age groups is creating what Kohn calls “praise junkies,” [17]. When rewards are offered for completing work in a course, the student can often become motivated to chase the gold sticker, the verbal praise, or other indicators of a job well done without paying attention to the job that he is completing. This neglect of the job at hand can lead to more tentative performances in the future, and risk avoidance in order to keep earning praise. This risk avoidance was also found by educational researcher Harter, who found students would choose to tackle

less difficult tasks whenever possible in order to keep earning praise [16]. Praising current performance can also lead to a decrease in future performance. This is caused by both “the pressure to ‘keep doing a good job’... [and] because they are less likely to take risks - a prerequisite for creativity,” [17].

With such risks created by over-emphasis on praise, it is essential that new education programs focus on alternative ways of acknowledging student achievement while still encouraging them to dig deeper into the material. Kohn suggests just that: acknowledging what a student has accomplished, by “[providing] feedback - not judgment,” [17] or praise. Additionally, Kohn recommends focusing on follow-up questions and encouraging deeper research. By looking more closely at the material involved, the student is once again engaged in the material he has completed rather than focused on the praise of an instructor.

### **3.5 Instructor Involvement and Support**

The role of the instructor in the classroom is critical, and is perhaps one of the most vulnerable elements of an online classroom. Replicating the presence that an instructor has for tens or hundreds of students in a lecture hall for an online experience is difficult. Therefore, harnessing the most salient elements of the instructor’s role and focusing on their deployment online may aid in the success of online education programs.

As I explained in the Presentation Style section, having an adaptable curriculum is incredibly valuable for students’ learning experience. Professor Jacqueline Brooks investigated the strength of instructors’ adaptations to student understanding. Universally, she found that the instructor has the best tools at hand to “adapt curriculum tasks to address students’ suppositions,” [11]. She goes on to add that, without such adaptations, “most students will find lessons bereft of meaning,” [11], despite how enticing the materials might be.

Similarly, access to the instructor for clarification and support questions is pivotal in a successful classroom. Indeed, the Department of Education’s research found that

programs that involved online question-and-answer forums which were monitored by instructors and TAs yielded far better student experiences than those systems without such interactions. However, it is worth noting that there was relatively little benefit in adding synchronous communication opportunities: the asynchronous communication on discussion boards was just as effective [24]. The biggest risk, then, becomes scaling: adequate response times require that there be enough instructors involved in the program to keep pace with the number of students enrolled. Alternatively, programs could investigate using peer instructors to provide feedback to other students more rapidly.

### 3.6 Community

Just as a connection to the instructor improves the learning experience, so too does a connection to the other students in the course. Providing opportunities for students to both interact and actually work together on course material leads to better academic performance across the board. Incorporating these opportunities into online courses is another element of creating successful programs.

Numerous studies have shown the positive benefits of interaction between students. Deslauriers' research on introducing active, collaborative work opportunities into physics classrooms yielded dramatically improved testing scores [23]. Greenberg's synthesis of good educational problems states that an optimal problem-solving opportunity "benefits from (as opposed to being hindered by) group effort," [15]. Incorporating such group-oriented problems and assignments into online programs will benefit all students engaged in the program.

Similarly, students are a resource to one another: when instructors are not available, fellow students can often provide support. The Department of Education's research found that students generally benefited from having the opportunity to interact with other students in the courses they were taking. As with instructor interaction, the timing didn't need to be synchronized - asynchronous discussion boards were just as effective at fostering community and supporting long-term retention [24]. While

one of the simpler elements to build, supporting and fostering an online community amongst the students in a course will help to improve the learning experience of the students in that course.



# Chapter 4

## Specific Courses

For my evaluation of Coursera, edX, and Udacity, I examined four different courses. The first three courses I examined were engineering courses from each of the three programs: edX's 6.002x, Udacity's CS253, and Coursera's Software as a Service. I then went on to examine Coursera's Fantasy and Science Fiction course in order to see how Coursera adapted its program to handle a humanities course. With only four courses to examine I cannot perform an accurate quantitative analysis or comparison; I instead aim to provide detailed qualitative analysis. For each course, I documented how the instructor distributes information, how students submit work, and all of the other supporting facilities implemented to enrich the experience.

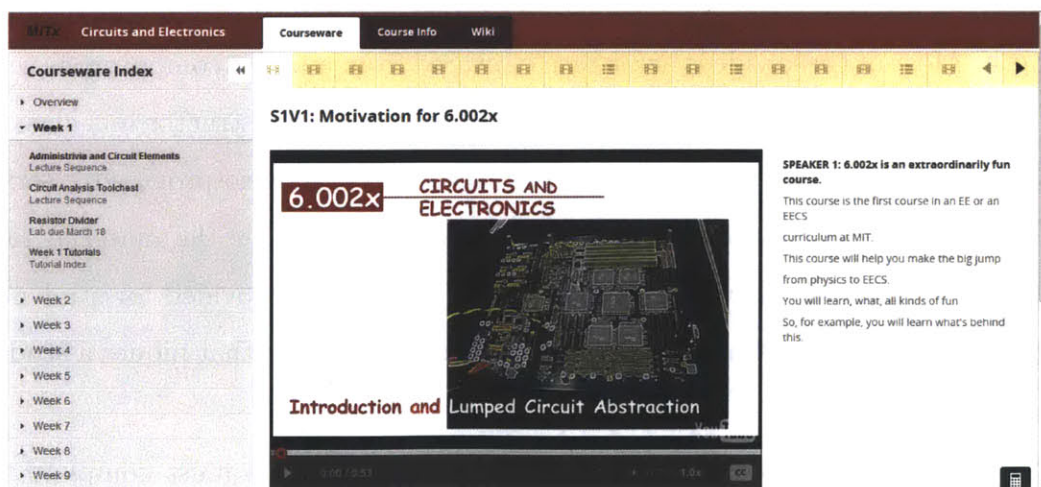


Figure 4-1: A sample lecture from 6.002x. A series of short video lectures are ordered, with a handful of exercises in between, for students to work through in sequence.

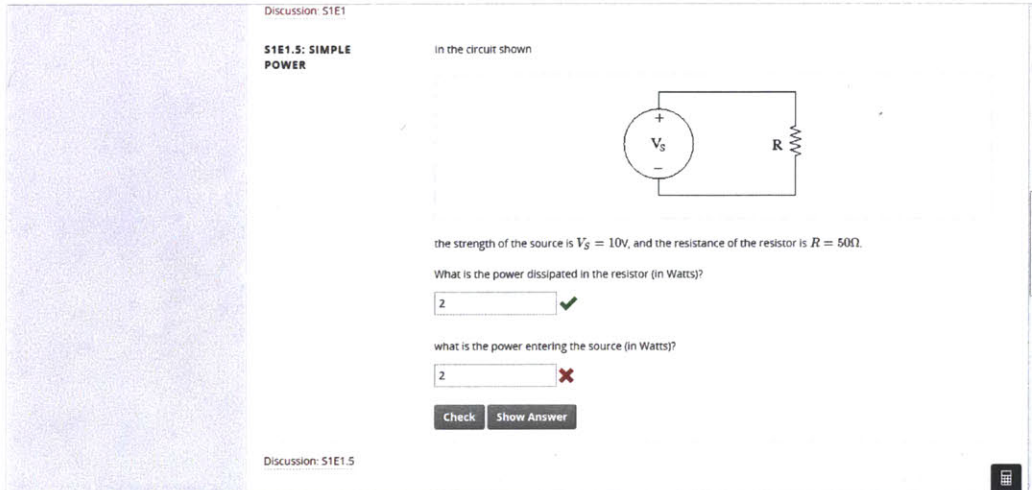


Figure 4-2: A sample homework assignment from 6.002x. The online exercises allow for the user to check input answers, receiving immediate feedback on the correctness of those answers.

## 4.1 6.002x: Circuits and Electronics, by edX

EdX's 6.002x is a fourteen-week long course, but is presently not in session. The previous semester's materials are still available for practice use. I am therefore able to report on the full functionality of 6.002x despite being unable to enroll in the class during its operation this fall.

6.002x uses video lecture series as the primary way to present information. These lecture series are composed of many small video segments, most less than five minutes in length. Most of these videos are screen captured from a tablet computer, as seen in Fig. 4-1, but a few demonstration segments are videos of the instructor in a classroom with students. In addition to lecture series, the instructors also provided a series of video tutorials on the fundamental concepts required to tackle the material taught in the class. There are also a series of secondary references provided for students on 6.002x's wiki page, providing background reading on any topic that piques a student's interest.

In order to get credit for taking 6.002x, enrolled students must complete three tiers of assignments: mini quizzes, labs, and midterms. The mini-quizzes are small sets of exercises built into each lecture series. As shown in Fig. 4-2, the exercises can

be checked, at which point they provide the student with the correctness of his answers. The lab assignments work similarly, checking the students' input answers and lab layouts for correctness. In both cases, students can re-attempt the assignment as many times as they like. The midterms (one midterm and one final exam), meanwhile, are more restricted: each answer can only be checked up to twice; thereafter, the program will not offer feedback to the student until after the entire midterm is submitted.

There are two main avenues for student support in 6.002x. First, for each question, there is a dedicated discussion board upon which students can ask one another for help. Second, the course wiki also has multiple sections dedicated to interaction with and feedback from students. This provides students with avenues for tackling both specific questions on particular assignments, as well as more general questions or feedback for the course at large [7].



Figure 4-3: A sample student's progress page on CS253. As students view lecture pieces and complete assignments, the progress trackers update in real time to remind the students of what they have completed.



Figure 4-4: A sample lecture mini-quiz from CS253. Most lectures in the course have an embedded mini-quiz that offers textual feedback on the correctness of the submitted answer.

## 4.2 CS253: Web Application Engineering, by Udacity

CS253 is a seven-week long, open-enrollment course. This means that it does not have any specific start or end date, and students can spend more or less than seven weeks on the course if they choose. I was able to access all of the materials used for CS253 easily, documenting all of the features it provides for students to use.

CS253 uses video lectures as the primary form of presentation. A series of mini-lectures on specific topics, each only a few minutes in length, are strung together into individual units. These lectures are usually screen captured videos from a tablet. CS253 also incorporates videos of the instructors in what are called “Office Hours.” These videos are recordings in which the instructors answer questions they have received from the students on the forums. These videos are not still being produced: new questions on the forums are only answered by instructors in text, not in video. The final major component of information comes from each student’s progress page, as seen in Fig. 4-3. On the progress page, a student can get a full understanding of what work he has completed and what he has yet to do in order to succeed in the course.



Students complete work in two steps for CS253: in-lecture quizzes and online code deployments. The in-lecture quizzes are single questions embedded directly into most of the lecture videos, as shown in Fig. 4-4. The quizzes provide immediate feedback on the student’s input, and can be attempted any number of times. Online homework submissions involve substantially more work: students are responsible for deploying websites on an online web server provided by the course. These deployments are then evaluated and graded electronically; the grades are visible to students on the progress page.

In CS253, support for student questions is handled primarily through the discussion forums. While there are video answers to the most common questions, other questions are handled on the forums by both fellow students and the instructors. Also of note are the interdisciplinary opportunities that Udacity offers to its CS253 students. A sister course, CS212, has assignments for which CS253 students can provide insight and guidance. Udacity created special forums for these interdisciplinary projects: CS253 students can use these forums to mentor the students in CS212 [8].

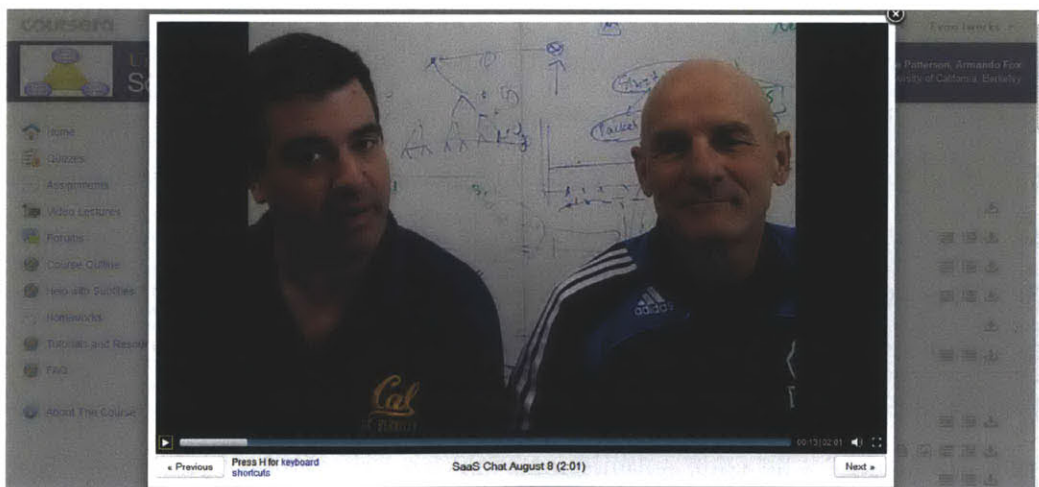


Figure 4-5: A sample lecture from Software as a Service. The lectures in the course blend live video segments with screen capture of lecture slides.

Latest Forum Activity		Last Post	Votes	Posts	Views
Thread Title / Original Poster					
HW3 difference with Autograder Sebastian Martinez (Student)		Tobe 19 minutes ago	0	4	66
HW3 - Autograder give 'undefined method' message Quang Le (Student)   autograder   hw3   undefined   method		Emerald Chung 1 hour ago	0	5	96
Homework 3 Autograder Result Help Robert Marke (Staff)   hw3		Mrosław Horbal 1 hour ago	18	2	477
Homework 3 xpath error Ziad Munir (Student)   homework   error   3   xpath   table		Thor Wolpert 2 hours ago	0	2	14
No idea what's problem in my homework 3 vincentzheng (Student)   homework   3		Thor Wolpert 2 hours ago	0	3	35
I give up HW3 Josep (Student)		Ahmad Tibi 3 hours ago	0	2	50
Cucumber example: Graphical Overview (3rd version) Peter Sorenson (Student)   cucumber   ELLS		Ahmad Tibi 3 hours ago	18	5	318
Bug in the canonical solution to HW3? Krishna Kumar (Student)		Anonymous 3 hours ago	0	4	81
Is Saas-book essential? Meenakshi Sundaram Ramakrishnan (Student)   book		Lao Solorzano 3 hours ago	0	8	175
Virtual machine vs local setup Jonas Carbaum (Student)   Git   ruby   rails   heroku   mac   rbenv   oahub   bundler   bitbucket   homebrew		Joao Antonio Ferreira 3 hours ago	6	12	464

Figure 4-6: A selection of posts from the forums of Software as a Service. All users can post questions, and veteran contributors are able to perform additional moderation tasks to keep the forum in order.

## 4.3 Software Engineering for Software as a Service, by Coursera

Software as a Service is a five-week course offered by Coursera, starting on the second week of July. I was able to enroll partway through the course's duration, gaining access to all of the materials used in the course.

Coursera's Software as a Service course communicates with its students through video lecture series and E-mails. Each week, the instructors release a series of short video lectures on the week's new content. These videos are mostly screen captures of a narrated Powerpoint presentation, and range from five to twenty minutes in length, on average. From week to week, the instructors provide news and updates about the course structure as live videos, as in Fig. 4-5. Additionally, each week the instructors send out E-mails to all enrolled students with updates on the class and the assignments.

Student assignments for Software as a Service come in the form of code submissions and online quizzes. The code submissions make up the bulk of the work. Students submit code to the online program, where it is electronically graded and scored. Students can see their scores update in real time on the submission page. Students

can resubmit code once in order to improve their score. Software as a Service also uses online quizzes, in which students answer a series of multiple-choice questions about the material recently covered in the class. The quiz is graded upon submission, and will offer some canned feedback to students about common mistakes. Students can retake each quiz once to improve their score, though the questions do not change.

Software as a Service relies heavily on its discussion boards as a way to communicate with the students. The boards are active with both students and instructors, as questions and answers are exchanged rapidly across the system, as shown in Fig. 4-6. Clear signposting on these forums allows students and instructors alike to quickly sort through the many questions on the forum for those that still need answers, or those that have been answered, or those that need more follow-up information [1].

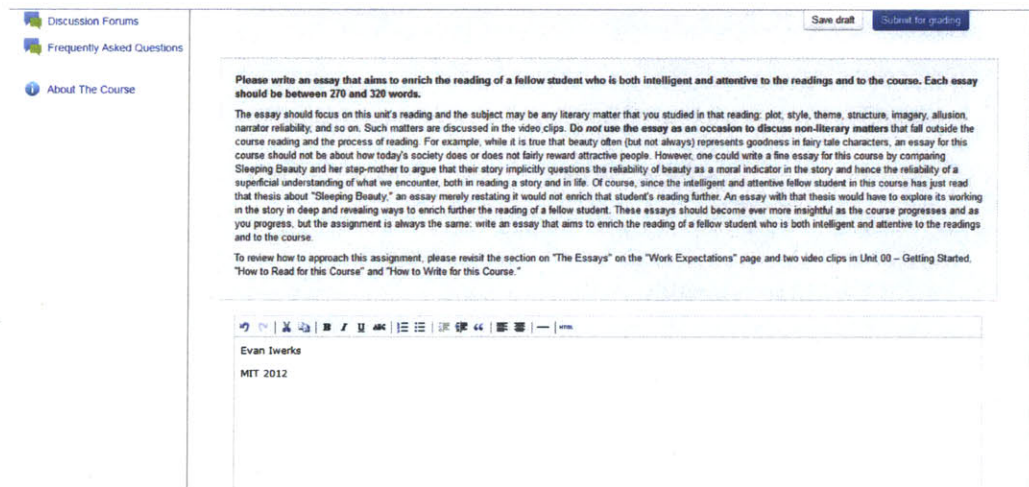


Figure 4-7: An essay entry prompt for Fantasy and Science Fiction. The essays for the course are entered here and, unlike all other programs examined, are not graded automatically.



**Evaluation of the above answers**  
 Note: this section can only filled out the evaluation phase.

Please indicate in 30-150 words your judgment of the FORM of the essay you have just read. FORM here refers to matters of grammar, usage, and structure. Are the sentences grammatically correct? Are the words properly used? Is the exposition and argument laid out clearly? An ideal response would note one aspect of Form that the writer does well and would profit by continuing and one aspect of Form that the writer would profit by improving in ways you make clear.

Please grade the FORM of the essay you have just read on a scale of 1 to 3. FORM here refers to matters of grammar, usage, and structure. Are the sentences grammatically correct? Are the words properly used? Is the exposition and argument laid out clearly? An ideal response would note one aspect of Form that the writer does well and would profit by continuing and one aspect of Form that the writer would profit by improving in ways you make clear.

Since everyone can learn to write better, at least 10% but no more than 30% of the grades should be 1. Everyone should strive for perfect grammar. However, if someone writes in ways that are particularly vivid or uses particularly incisive key terms to focus the argument or in some other way is outstanding in usage or structure, that essay should be awarded a 3 but no more than 20% of the grades should be a 3 because, by definition, "outstanding" is comparatively rare. Most grades should be 2.

Figure 4-8: An evaluation sheet for grading other students' work. With each essay, students in the course are expected to review the work of at least four of their peers in order to get their own work evaluated.

## 4.4 Fantasy and Science Fiction: The Human Mind, Our Modern World, by Coursera

Fantasy and Science Fiction is a ten-week course offered by Coursera, running from late July to late September. I enrolled partway through the course, and was able to document all of the materials used in the class. Fantasy and Science Fiction is the outlier course, providing some insight into the designs used to handle humanities courses online.

Fantasy and Science Fiction's instructor uses a two-stream approach to communication: video lectures and E-mails. Each week, the instructor sends out an E-mail containing information about the coming week's reading and writing assignments. Additionally, the instructor provides a series of video lectures that discuss the content of the most recently completed reading assignment. These videos range from five to twenty minutes in length, on average, and are all videos of the instructor talking to the camera.

Student work for Fantasy and Science Fiction revolves around the two-step assignments each week: writing an essay, and then evaluating other students' essays. The first step is straightforward enough, with the students entering their text responses



in the field shown in Fig. 4-7. Later in the week, the students will be notified by E-mail that the writing period has ended, and the evaluation period has begun. At this point, each student who wants a grade on his essay is expected to evaluate at least four of his peers' essays. The evaluation form, shown in Fig. 4-8, includes both short-answer fields for comments and numerical scoring components. By having each student evaluate multiple essays, the program aims to provide multiple sets of feedback for each of the students in the course.

Fantasy and Science Fiction also includes a discussion board for students to interact with one another and with the instructor. The board includes multiple forums where students discuss the texts and related readings associated with the class, as well as some forums dedicated to students getting additional writing support from their fellow students. Additionally, students looking for more readings on particular topics or genres can turn to the instructor-provided reading lists [1].



# Chapter 5

## Comparative Analysis

In this chapter I evaluate the relative strength of each of the classes I examined in each of the six characteristic categories I defined. Each program shines in at least one of the categories: Udacity has the strongest presentation structure, as well as an excellent long-term goal structure, while edX provides the strongest community and instructor support and Coursera offers the most innovative, progressive grading system available. I have summarized some of the features I found strongest in each program in Table 5.1.

Course	Key Features
6.002x	Narrow-scope discussion boards and varied instructor presentations
CS253	Diverse instructor presentations and incorporated goal programs
SAAS	Goal programs and Instructor response videos
FSF	Peer-reviewed assignments and active discussion boards

Table 5.1: This table shows the some of the key features of 6.002x from edX, CS253 from Udacity, Software as a Service (SAAS) from Coursera, and Fantasy and Science Fiction (FSF) from Coursera. I found these features to be particularly good examples of the characteristics I identified.

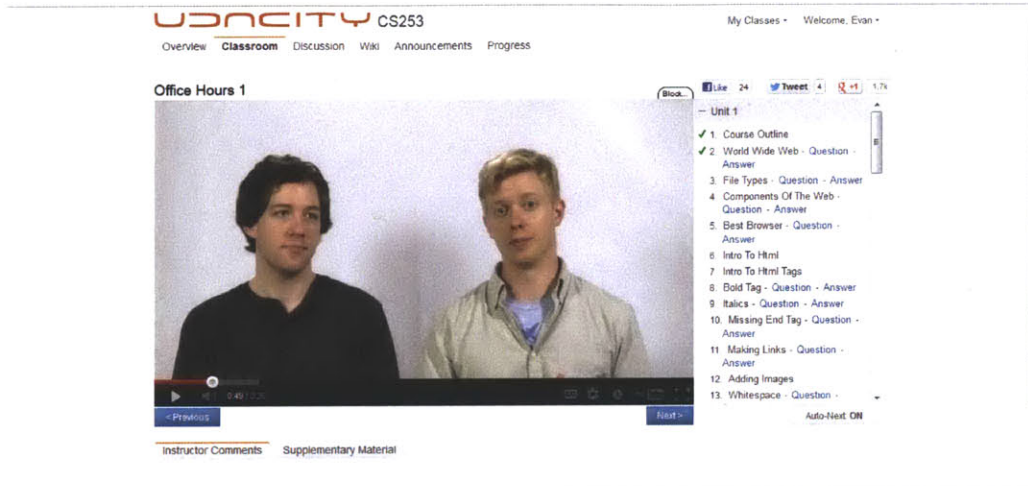


Figure 5-1: The highly targeted lectures of CS253, as well as the variety of supplementary presentations and mini-quiz feedback moments provide the strongest presentation package seen in all of the examined courses.

## 5.1 Detailed Analysis: Presentation Style

I found Udacity's CS253 to have the most effective approach in this particular category. CS253 brings together a wealth of different forms of presentation to the user, allowing for a varied experience that meets the needs of many different types of learners. The video lectures provided are each narrowly scoped and accurately titled, making searching for topics that need more review easy for students. The addition of videos to answer common student questions, as shown in Fig. 5-1, as well as the lecture-by-lecture mini quizzes provide an active learning experience to support information retention. These tools, in addition to the standard provisions of all the programs make CS253 the standout presentation course.

EdX's 6.002x has many merits to its presentation style as well, though it lacks some of the fine tuning offered by CS253. In particular, the lecture series in 6.002x are not as easily scanned to find particular topics of interest - many videos have titles that are similar, and the titles are hidden from view until the video is selected. This causes much more manual searching compared to the other programs. There are many supporting tutorials, however, and 6.002x does provide substantial feedback with its in-lecture quizzes to support student focus and long-term retention.

Coursera's courses each have a few issues when it comes to presentation. On the one hand, Software as a Service provides a couple supplementary resources for students to explore, but could incorporate them more gracefully into the lecture series. On the other hand, Fantasy and Science Fiction has very broadly-scoped lectures that are hard to browse for particular pieces of information. Both courses lack opportunities for active learning - there are no mini-quizzes throughout the lectures. There are also fewer tutorials and support videos available.

## 5.2 Detailed Analysis: Presentation Size

The size of individual presentations is tied very closely to their overall style; Udacity's CS253 is particularly effective in its presentation timing. Udacity's lectures are sized in such a way to provide very narrow-scoped discussions of individual topics. By restraining focus to these small, critical topics at each step, students are able to easily pace how much content they want to consume, and can very quickly acquire a break point when it is time to stop working on the course for the day. This flexibility and targeted scope of lectures demonstrates a focus on student-centric presentation in CS253's design.

6.002x has varied presentation lengths, which accommodate the varying lengths of the topics covered. This makes finding adequate breaking points harder, but not impossible. Most videos are still short enough to hold students' attention for the entire duration. Software as a Service has even longer lectures, that are more broadly focused than 6.002x's lectures. Fantasy and Science Fiction's presentations are the longest of all, often stretching for fifteen minutes or more. These lengthier presentations are not inherently bad design, but rather a hindrance to the students' convenience; where possible, I believe that more presentations with the shorter, narrower-scope design of CS253's lectures would be an improvement.

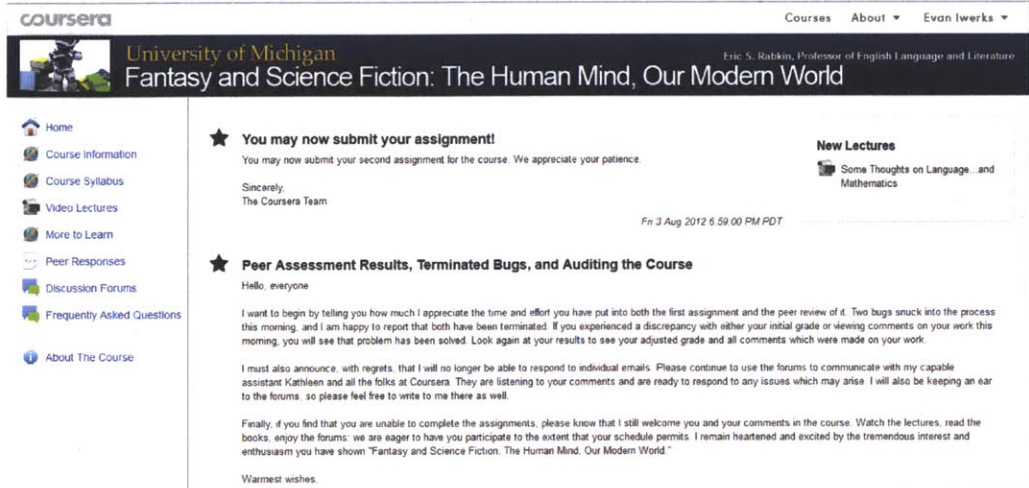


Figure 5-2: The emphasis on peer feedback and evaluation puts Fantasy and Science Fiction far ahead of its peers by providing qualitative feedback to its students - a vast improvement over electronic grading.

## 5.3 Detailed Analysis: Grading and Evaluation

In terms of evaluating students, Fantasy and Science Fiction has the most innovative approach of the examined courses. The inclusion and heavy emphasis on peer review provides real-time, qualitative feedback for the students in the class. This allows students to not only see where their current performance lands them, but also read what they need to do in order to improve their work for the future. As Fantasy and Science Fiction continues to iterate on the peer review model, as shown in Fig. 5-2, the value of the program must be clear to the instructors. Just as Kohn stressed the importance of providing qualitative feedback [18], Fantasy and Science Fiction recognizes the importance of getting that feedback to students when an instructor isn't evaluating every assignment.

Meanwhile, 6.002x, CS253, and Software as a Service all rely solely on electronic grading to evaluate the performance of students. 6.002x and CS253 stand out by providing more opportunities for feedback through the mini-quizzes they use. These quizzes don't give the qualitative feedback of why an answer is correct or incorrect, but by having so many narrowly-scoped questions, students can begin to piece together which topics they understand and which topics they're still struggling to master.



Software as a Service, meanwhile, doesn't provide any feedback until after the students complete the much longer weekly quizzes, which occasionally provides a few canned blurbs of text explaining common pitfalls - an insufficient evaluation to help students grasp where they're strong and where they're weak. There is little attention given to how the students arrive at their answers in these technical courses; only that answer that is considered in the automated grading system.

Qualitative feedback could be provided in these technical courses through the discussion boards. When I examined these courses, the discussion boards had very few qualitative questions about the assignments. The more common threads were request for answers to those assignments, without regard for the cognitive reasoning behind those answers. Mirroring the experience of peer review on the discussion boards would require some more work from the instructors to integrate and encourage the technique.

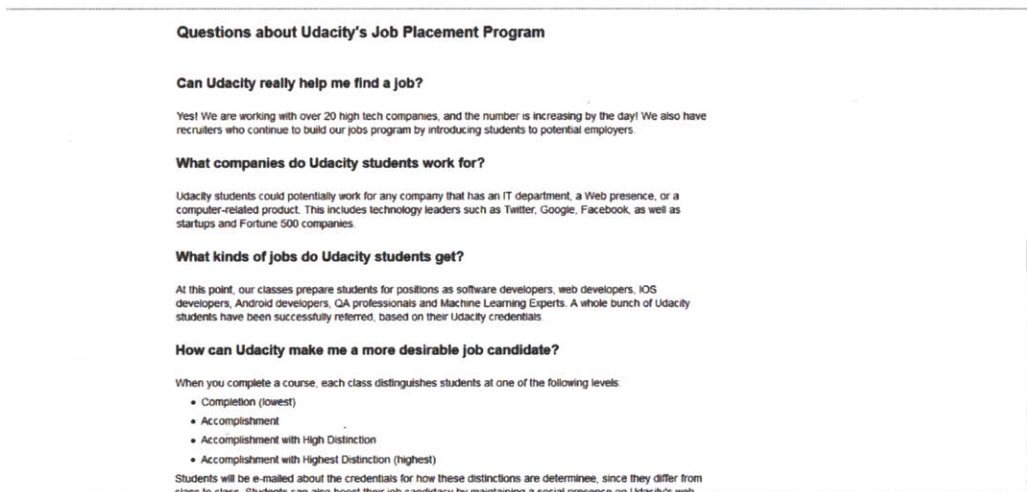


Figure 5-3: Udacity places a heavy focus on long-term goals for its students by providing the Job Placement Program. Through this program, students can bolster their resumes with the courses they take and have them recognized at a variety of high-tech companies.

## 5.4 Detailed Analysis: Rewards and Goals

Rewards and Goals needed to be examined on two levels: the short-term, within the course goals, as well as the long-term, beyond the course goals. In both categories

Udacity's CS253 has the most innovative approach, but for different reasons.

With regards to short-term goals, CS253 provides students with the most comprehensive progress sheet available in all examined courses. The top-down perspective showing overall completion, with as much detail as is desired on each sub-component of the class, gives students a very strong grasp of where they are in the class without ever stepping into dangerous judgment or praise pitfalls. Coursera's courses both show students' assignment-by-assignment grades, but getting a larger picture of performance is left to the student. 6.002x also doesn't show how performance on each of the assignments will aggregate into the total grade. Additionally, it is worth noting that all of these courses do offer certification to students upon completion, though none of the certifications are officially endorsed by any university.

When considering long-term goals, the discrepancies between the three programs becomes far more pronounced. Udacity is the only online program that has a long-term goal designed into its courses: the job placement program. This program, described in part in Fig. 5-3, helps current students find jobs after completing courses at Udacity. The program combines the completed courses with the student's uploaded resume, and then sends those credentials to a collection of partnered high-tech companies. This allows students to put their education to practical use in a rapid way, as well as in a way that is already recognized by those partnered companies - a big relief to students that are suspicious of how companies would see an online education.

In contrast, Coursera has a minimalist degree program potential, and edX has none at all. By virtue of having over one hundred available courses by the fall of 2012 [1], Coursera naturally has some unofficial degree programs that students could take. For instance, a series of progressively harder classes in the computer science disciplines could provide an overarching education that hiring companies might recognize. edX has only seven courses in the fall of 2012 [4], which does not yet provide for any long-term degree potential. There is course-by-course certification from all edX courses and some Coursera courses, but these are still short-term goals.

Of course, long-term goals do not influence the success of individual courses. I do think that the long-term vision of these education programs is important, so I



have included my thoughts on the topic. Nevertheless, as Anderman found, it is important to pursue the material of the course, not the reward at the end. I believe that the differing long-term goal opportunities provided by these programs do not substantially alter the teaching potential of the individual courses.

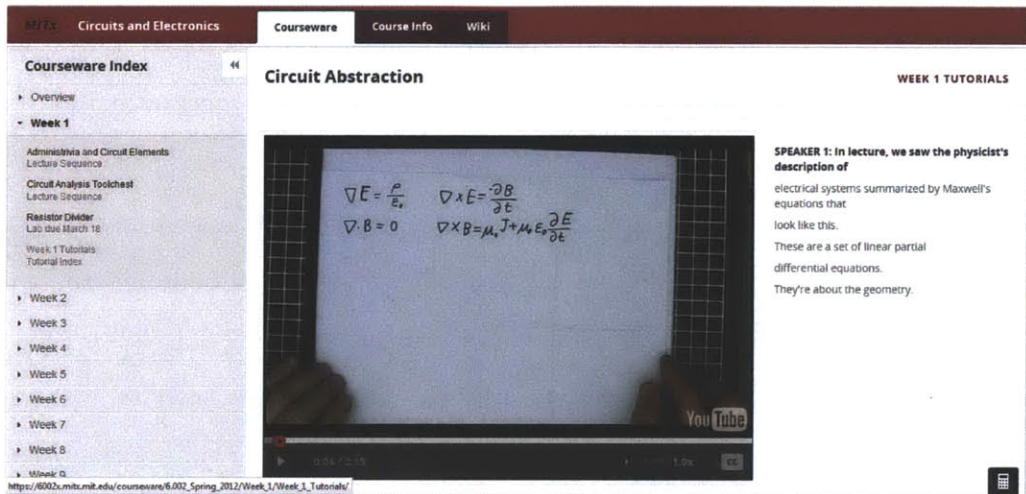


Figure 5-4: 6.002x provides many instructor-driven support tools, including guided tutorials through content. This, combined with the narrow-scoped discussion boards and active wiki page allows for superior instructor involvement in the learning experience.

## 5.5 Detailed Analysis: Instructor Involvement

EdX's 6.002x has an exceptional infrastructure to facilitate instructor support and interaction. Perhaps the most notable addition is the inclusion of the extra tutorial videos, seen in Fig. 5-4. These tutorials were provided to fill in gaps that the students found in the course's lecture series, as well as provide extra practice opportunities for students. 6.002x also has many narrowly-scoped discussion boards, which instructors can track to provide targeted responses whenever the community is stuck on a particular problem. Finally, the very well-integrated wiki has a wide variety of sections where students can pose questions to the instructors directly, making sure that students' comments and concerns are heard and incorporated into the future iterations of the course.

Coursera's courses also have some instructor support, but not quite as much as

6.002x. Software as a Service has a very active discussion board, with hundreds of posts receiving responses from the instructors. Additionally, the course has constantly adapted and updated in response to student feedback, and these updates are shared with students through instructor-written E-mails and video clips. Fantasy and Science Fiction provides similar feedback to students as changes are made to the class (most notably, the addition of a “Works Cited” section in each essay submission). The discussion boards for Fantasy and Science Fiction receive far less instructor interaction, however - most of the communication on those boards is between the students.

Udacity’s CS253 has less provision for instructor support largely because of the time element. All of the courses on Udacity are open-enrollment, so there is no particular end date for the course. That said, all of the materials for CS253 have already been put online. While the discussion boards show some activity, there are no new videos, and no alterations made to the existing structure of the course. Likewise, over time, the instructors will invariably be pulled into other projects and will no longer provide adequate support for the course. Udacity therefore has the weakest support on the part of its instructors once the courses are fully released - the open enrollment generally leads to a reduction in instructor focus on the course over time.

## **5.6 Detailed Analysis: Community**

6.002x provides the closest thing to collaborative work environments seen in an online course with its narrow-scope discussion boards. By narrowing the focus to individual problems within each assignment, students in the course are able to discuss the problem with a very high level of focus, rather than getting distracted by the many other common questions that fill broad-scope discussion boards. Also, the ability for students to edit and manage the wiki creates a second avenue for students to work together and share ideas online. These two tools bring edX’s program to the forefront of community building among the examined courses.

Coursera’s Fantasy and Science Fiction is also a course with strong community-building tools. The peer review process is a great way to foster interaction between

students in and of itself. Moreover, the conversations between students on establishing standards and explaining feedback on the discussion boards indicates a great amount of shared interest in success on writing essays. These discussions have arisen naturally, without instructor intervention, and continue to be a great format in which students can interact and learn from one another.

Coursera's Software as a Service, meanwhile, has fewer opportunities for community building. Each assignment is independent, and there is much less direction on the discussion boards for focused conversations on particular sticking points within a problem. There are certainly some involved conversations on the discussion boards, but it is by and large less successful than Fantasy and Science Fiction's conversations. With no other real link encouraged between students, Software as a Service remains a relatively independent course experience.

CS253 again suffers from the problem imposed by the open enrollment structure. While the discussion boards easily had the activity of Coursera and edX's courses at one point, they are far less active now that the class has been available for a few months. These discussions are likely to die down even more as the course's life goes on, with fewer and fewer students beginning the course on each coming day. Therefore, the discussion boards become more of an archive of past students' experience, rather than an active community for students to join.

## 5.7 Final Synthesis and Caveats

In all, each of the courses has some impressive strengths and some weaknesses. Udacity's CS253 offers great presentations and an excellent long-term goal structure, but lacks the vibrancy of active instructor and community involvement. EdX's 6.002x provides some solid presentations and excellent discussion boards, but does little to innovate on effective student evaluation or in providing goals for its students. Coursera's Software as a Science offers some encouraging rewards and has strong instructor support, but lacks adequately scoped presentations and appropriate evaluation. Lastly, Coursera's Fantasy and Science Fiction has student-driven discussion boards

and provides innovation on the evaluation of students, but doesn't sufficiently vary its presentations or engage students with the instructors.

As a final note, I am interested in these results only to identify how to strengthen these and other programs in the future. I have only examined a few courses and therefore do not mean to evaluate or assess any of the programs as a whole. Rather, I believe that by looking at these characteristics I have identified and the courses I have examined in tandem, I can provide some insight on how to improve online education programs in general. I will elaborate on how to make such improvements in the next chapter.

# Chapter 6

## Reflections on Improvement

With an understanding of the different teaching styles employed by the top-tier online education programs, I now reflect on how to improve the approaches these programs use. I here deliver constructive feedback for each of the existing programs to use in future iterations of their courses. I place a particular emphasis on strengthening the parts of the programs that I view as needing more work, such that they can provide a whole, well-rounded experience for their students. I also provide insight into the construction of a course focused on educational performance.

### 6.1 Improving Coursera

I think that one of the biggest improvements Coursera could make is to incorporate more active learning opportunities. Unlike edX and Udacity, the Coursera courses do not have integrated mini-quizzes with their lectures. There are also very few opportunities for students to work together on assignments - there are no group projects or exercises. As it is one of the tenets of Coursera's foundational pedagogy, active learning could use a second look to make sure it is integrated into the courses.

To bring in more active learning opportunities, I think that the lecture series are the first place to investigate. Instead of the long blocks of videos followed by a single, many-question quiz, one could break up the quiz into a collection of miniature exercises interspersed between the associated lectures. By breaking up both the exercises

and the lectures more finely, the content will also become more accessible. That is, students could identify and focus on those content areas with which they are struggling. Group exercises are difficult to implement, but can be included as optional projects to get more practical, hands-on experience with larger assignments. For instance, the Fantasy and Science Fiction course could pair up students to write papers for two sides of a debate topic, and then write response articles based upon the results of their partner's initial paper. Software as a Service could incorporate optional labs in which students explore different implementation techniques. Each student could create a project using the same specifications but different implementation tools; the closer the resulting projects, the better. By incorporating more of these opportunities to reflect on material as it is heard for the first time, as well as opportunities to work collaboratively with classmates, I believe Coursera may be able to better support its students.

Coursera might also benefit by giving some additional attention to the long-term goals of its students. As the only program that does not have guaranteed certification from all of its courses, it has somewhat less to offer to students that want to have a tangible take-away for completing the course. Many students drawn to these programs will want to gain more than an isolated understanding of Software or Fantasy literature: they will want a comprehensive knowledge, some marketable skills, or some other way in which they can enrich the rest of their lives. This can be done on both a course-by-course basis and a discipline-by-discipline basis. With each course, instructors can support the goals of their students by establishing marketable skills that are developed in the course, as well as examples of that skill set applied in industry. Alternatively, instructors could provide other enrichment exercises that allow students to explore beyond the core material of the class. As a second step, Coursera could organize the various disciplines to show how students can build a degree program could greatly enhance students' long-term involvement and understanding. Larger degree programs can transform a student's online education from taking a couple of computer science courses to developing a full, deep understanding of computers and the technology behind them. I believe that incorporating some more information and

direction for students to use in setting their own goals will help to improve student engagement and involvement in Coursera's courses.

Lastly, I think that Coursera's collaborative grading policies have great potential, and can definitely benefit from being employed in more courses. As the most promising form of evaluation I have seen in this analysis, the more experience and practice the educational community can get with collaborative grading, the better. The engineering disciplines should try to involve more peer review opportunities, be it through testing each other's code or by interacting on review-focused discussion boards.

## 6.2 Improving edX

EdX has a lot of potential strength that I feel students will recognize more readily if there is more cohesion between the courses. Each of the individual courses that they offer is well-developed, presented, and supported, but that is the extent of edX's larger program in the fall of 2012. By providing a deeper objective for its students, either through more connected courses or through more enrichment assignments, edX will feel more like a comprehensive education program. I believe these changes will help edX reach their ultimate goal of providing "The Future of Online Education," [4]. I also believe that the evaluation processes edX is currently using could be reviewed with the intent of getting more qualitative feedback into the students' hands.

To tackle the process of establishing goals for its students, edX needs to look deeper into the objectives it wants to provide. For instance, edX could follow in the vein of Udacity with an emphasis on marketable skills and job placement. If this is the chosen route, edX would need to emphasize the skills its courses teach and provide a deeper structure for practicing those skills. Alternatively, edX could aim to provide a more general education opportunity just as its sponsoring universities do. In this vein, the courses that edX offers could be connected to one another more closely. Currently, I feel that each of the seven courses offered on edX is isolated from the others. If edX organized the courses together into more closely-linked groups,

students would be able to see more cohesion between the different courses they can take. This increased cohesion is likely to make students want to keep interacting with the program - there's more material for them to discover in the same field if they liked what they already took. EdX isn't yet at a stage where it could pursue full degree program offerings or other longer term projects for students to undertake, but I believe the current structure could use some more focus on unifying the courses that the different universities are offering.

Additionally, I think that improvements to existing courses are also possible. The grading and evaluation process, in particular, could be refined in order to better support learning. I think the emphasis needs to be drawn away from correct/incorrect feedback, and instead oriented to provide more qualitative feedback of where a student is succeeding and where he is struggling. To do this, edX could pursue a collaborative grading system. By having students evaluate one another's code and circuit layouts, human-provided feedback can be generated in place of static check marks. Alternatively, edX courses could incorporate dynamic quizzes and assignments. Dynamic quizzes are those quizzes that change the questions asked based on the responses given by the students: the more correct responses, the harder the questions get. These quizzes aim to identify where exactly a student's limit of understanding lies. By incorporating this kind of quiz structure into its courses, edX would be able to provide tailored feedback and instruction to each student better than the current structure. The feedback from the dynamic quizzes would still be canned, just like the correct/incorrect marks, but would have some specificity for the students. I believe that these dynamic quizzes would give students more insight into what material they have mastered and what they still need to study. Indeed, I believe that dynamic quizzes are a valuable asset to any of these online programs; while the cost is significant - many more questions need to be written than for static quizzes - I think the benefits are valuable.

Finally, I believe that the community of edX has a lot of potential. With the best supporting resources for community amongst all the investigated programs, edX should take advantage of this strength for the betterment of the student experience.



Group exercises would fit very easily into the structure of edX's courses. Leveraging the community both for these collaborative projects and collaborative evaluation would greatly improve the learning experience.

## 6.3 Improving Udacity

In contrast, Udacity has what I believe to be the least established community. As a by-product of the open enrollment structure of Udacity's courses, students come and go rather than being clustered together for a single one-time opportunity to experience the material. This structure is likely more convenient for the students, but might limit their opportunities to learn collaboratively or get qualitative feedback from one another.

To cope with this complication, I believe that Udacity could incorporate a structure for improving and supporting a rotating community. One solution would be to deploy a live team to staff each course after it has completed, with the objective of maintaining the community and providing supplementary materials. Just as CS253 had "Office Hours" from its instructors during the weeks it was running, the continuous addition or even replacement of such video segments with the latest questions from the discussion boards would improve the sense of presence in the course. Alternatively, community can be built by continuing to pursue the between-course activities that Udacity has begun in a couple of cases. By linking the courses together, the community can shift from being just the students in CS253 to being the students enrolled in the CS department on Udacity. Above all, continued engagement from the instructors of the course - even if those instructors change over time - could help the courses feel valuable weeks after the presentations have been released. I think that the biggest vulnerability to a course is having that course feel outdated because the instructors or live team are no longer involved. By following these different community-building avenues, Udacity can tackle one of the hurdles on its path to provide a successful, lasting form of education.

In addition, I believe that Udacity can improve the feedback that it provides

to its students. In order to harness the power of collaborative grading, Udacity would need to have students synchronized in the program - a condition that it isn't requiring in the fall of 2012. However, the dynamic quizzes that I suggested for edX are also applicable to Udacity's vocationally-focused program. By constructing dynamic quizzes on the content of each unit, Udacity can give its students qualitative feedback on how their knowledge and marketable skills are developing. Identifying the strengths and weaknesses of the students could in turn empower the students to improve on the content that still challenges them.

While I believe that Udacity has the strongest presentation style amongst the investigated education programs, I think there is still potential for more active learning opportunities. Collaboration, again, is hard to incorporate with such a fluctuating student body. By the same token, having more opportunities to work together will encourage students to get engaged with the course material and with one another. A week-by-week sign up of students enrolled in the course and ready to tackle the next group assignment would be one structure that flexes to match the open enrollment design while still giving the opportunity to work with fellow students.

## **6.4 Building a Characteristics-Driven Course**

In order to build a better course, I first lay out the best structure to tackle the most difficult-to-incorporate characteristics. With these critical characteristics handled, I then turn to existing practices to support the remaining characteristics. By taking the already successful practices of existing systems and incorporating them into my design, the course as a whole becomes both easier to implement and easier to refine.

### **6.4.1 Focus on the Hardest Characteristics:**

#### **Evaluation and Rewards**

The first major task is to tackle the characteristics that I think are the hardest to employ. In all of the programs I investigated, evaluation of the students was still

relying solely on traditional grading systems. I think there is a lot of potential in using alternate evaluation methods that have been found to support student learning. Additionally, I think that the goals and rewards of programs that the course provides need to be considered carefully. Students likely bring their own reasons for wanting to study courses, but providing a set of high-level potential goals to students could also benefit them.

**Grading and Evaluation** Grading students is presently an unavoidable task. In my opinion, placing as little focus on the quantitative grade as possible is important. Especially with such a wide, diverse demographic of students, I believe that more qualitative feedback formats could support the learning of more students. And, as Kohn’s research indicates, simply adding comments to the letter grade doesn’t solve the problem; only those students who never saw a letter grade achieved an improvement in performance [18]. This is a dramatic shift from current style, but online courses are an excellent place to verify the validity of such dramatic shifts.

In essence, students need to get qualitative feedback on all of their assignments. A separate grade book can contain the particular number or letter grade, as completely hiding that information from students can seem disingenuous. Outside of that, however, I believe that the focus should be aimed towards dynamic textual feedback rather than electronically-graded assignments. I also support including more opportunities for constructive feedback from peers in any peer-reviewed assignments. This approach may improve the student experience, helping students acknowledge where they actually need to work, rather than ignoring the details and operating off assumptions implied by their letter grades.

**Goals and Rewards** While curiosity and other intrinsic motivators are the ideal reasons for students to enroll in online education programs, many students will likely enroll in pursuit of other goals as well. One approach is to follow Udacity’s lead. Udacity incorporates a heavy focus on practical tasks that can be completed after taking the course: for example, “CS262: Building a Web Browser” [8]. For many

students, there is merit both in learning about the abstract concepts as well as the real-world applications of those concepts. In particular, many students of online education programs may also be employed adults in industry. With a job at which they can apply and employ the applications they learn, those students may gain more from the course than they would have experienced with just the abstract concepts.

As an alternative for more general courses that are not so vocational in nature, motivation for students can come from instructors showing the intrinsic value of understanding the course's material and otherwise enriching their students' lives. For example, a literature course can spend time investigating the impact that the read literature has had on current literature. A biology course can encourage students to investigate the ecosystem of a local park (or some other, common environment). This is a more minor approach to rewarding students, but still achieves the basic objective: showing the students how the course material can impact other parts of their lives. Moreover, asking for student input on what applications they would like to see for the content they are learning would provide another level of engagement. That is, instructors could ask more questions about what students want to see, and then tailor a small set of presentations to fulfill those requests. This would support both the goals of the students as well as the community built between the instructor and the students.

#### **6.4.2 Integrate Successful Practices**

Rounding out the rest of the program is the next task. In these cases, a lot of the work has already been done by another program before this thesis. Taking advantage of this already-completed work will allow for a more complete, comprehensive educational experience for the students without the need for deviation from what practices are already accepted. Maintaining consistency can also benefit students: consistency can reduce some of the learning curves students encounter when trying a new program.

**Presentations** For presentations, I think that the approach of Udacity is the place to start. The high visibility of the lectures, the common opportunities to reflect upon

those lectures through mini-quizzes, and the employment of real-world tasks as assignments are all great decisions to optimize a course's presentation. I believe that the first two decisions are particularly important for any new online course: the lectures should be easily navigated and searched for whatever concepts the students want to see. Likewise, every lecture should be accompanied with reflection questions about that lecture to help students internalize the new information. The addition of a few dynamic quizzes to help students evaluate how much information they've mastered would also be beneficial. I also encourage the employment of reactive presentations, in response to either shifting goals amongst the students or trends of students struggling with particular parts of the course. Interaction with the students is important, and it begins with the instructors willingly adding to the expected track of the course.

**Instructor Involvement** Continuing in the vein of instructor involvement, I believe that 6.002x's structure has a lot of merit. By incorporating targeted discussion boards for every assignment and linking those boards directly to the assignment, instructors have a visual representation of where students are struggling based on what assignments get the most discussion traffic. In this way, 6.002x could be far more dynamic in order to meet the needs of the students. More tutorials should be incorporated, now targeting those most-difficult assignments according to the discussion board traffic. Overall, the role of the instructor is to act as a guide to the students as they explore the material of the course. Providing quality presentations is the first step, but tailoring the experience to support the students will lead to a better learning experience overall. No approach can tackle all of the questions of a student body this size, of course, but even a couple additions to answer common questions will be a great stride in the right direction.

**Community** Fostering an online community is certainly a challenging task. I think this is a good place to turn once more to 6.002x, learning from the targeted message boards for each question. By maintaining these narrow-scope boards, discussions between the students very quickly develop into deeper, content-focused conversations.

Adding to this structure, I would strongly recommend incorporating collaborative assignments into any online course. The assignment does not need to be difficult, but does need to emphasize interaction - it should not be a task that any student in the group can complete alone. My earlier examples of partnered debate assignments and multiple-approach program implementation assignments are some good options. Another opportunity for student community is synchronized video presentations. While videos are generally viewed asynchronously, a synchronous video program could connect a group of students together to a single video feed. Being able to pause the video feed and ask a fellow student about the video, in real time, would be an excellent way to get students thinking critically about what they're watching. I believe it would help to discourage passively listening to the lectures one by one. Synchronized video is a very hard problem, but still a potentially valuable tool if a solution could be implemented.

While this is not a comprehensive course construction, my intent is to provide insight into all of the key characteristics I have identified in this thesis. By providing example structures for incorporating each characteristic into a course, the next step is to simply select a course that one wishes to deploy online. With a course in mind, adapting these examples to that course should be relatively straightforward. Should some examples or suggestions simply not fit, emphasis on those most difficult-to-tackle characteristics will be the best way to maximize the learning experience for the students.

# Chapter 7

## Conclusion

In this chapter, I discuss good avenues for future work. I provide two particular paths for research that follow directly from the findings of this thesis, as well as supporting the success of the educational programs I investigated. I have also included a list of my contributions to conclude this thesis.

### 7.1 Future Work

Future work in the field of online education programs can diverge in many directions. With regards to the work of this thesis, I believe that there are two ideal paths of development that follow. First, I believe that there is a great amount to be learned by performing long-term research of the programs I investigated. Second, I believe that more research on alternative teaching approaches may provide online education programs with more insights on what works best for their students.

**Long-Term Investigation** The courses I investigated are all very new courses to the online world; they have not been iterated on or taught multiple times in the way that many traditional courses have been. As a consequence, my study of these courses lacks an analysis of progress through iteration. A more comprehensive analysis of these programs would require an investigation of the material for more than one semester. With a long-term study of this form, investigators could get closer to a

quantitative evaluation of the courses' teaching effectiveness. Additionally, this long-term study could analyze the value of iteration on these classes, discovering how courses change over time and how those changes affect the students' experience.

**Alternate Teaching Approaches** There are many articles detailing the effectiveness of active learning, collaborative assignments, and peer review for supporting student learning in offline classrooms [23], [11], [25]. However, the research of online classrooms is very minimal - the efficacy of these teaching styles in online courses is under-examined. An excellent next step for many of these online programs to take is to research one of these styles in detail. By performing experiments using their online courses as testbeds for these different teaching styles, these programs can both diversify the student experience and know more accurately which system is best suited for supporting their particular courses.

## 7.2 Contributions

In this thesis, I examined three free, online, university-level education programs: Coursera, edX, and Udacity. From these three programs, I investigated four different courses in detail: Coursera's Software as a Service, Coursera's Fantasy and Science Fiction, edX's 6.002x, and Udacity's CS253. I established six characteristic categories with which I could compare these courses: Presentation Style, Presentation Size, Grading and Evaluation, Goals and Rewards, Instructor Involvement, and Community. I then performed a comparative analysis of these courses, examining the relative performance of the courses in each of the defined characteristics. With these comparisons I identified the major strengths of each program, as well as some weaknesses. I then offered constructive solutions on how to tackle these weaknesses. I also established the steps to take in order to build ideal online courses. I lastly elaborated on the best avenues for future research in the field of online university-level education.



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