MOOC ON A BUDGET: DEVELOPMENT AND IMPLEMENTATION OF A LOW-COST MOOC AT A STATE UNIVERSITY

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Abstract

One of the biggest barriers to MOOC development is the large initial cost – sometimes exceeding $100,000 – and the possibility of never recovering that cost through course-related fees. This obstacle prevents many state universities and community colleges from creating their own MOOCs, denying faculty at those institutions the opportunity to develop MOOC-related content and to gain experience with this new teaching style. This paper presents a successful strategy for primarily undergraduate institutions to create their own MOOCs using local resources at relatively low cost. The authors discuss the development and implementation of Cal Poly Pomona's first MOOC, which was offered for 10 weeks during Spring 2014. The MOOC was an introduction to computer programming course and was open to everyone in the world for free. It was developed in stages over two years at a total cost of approximately $10,000 to the university. Significant savings were achieved by hosting the MOOC on a free platform (Blackboard CourseSites), repurposing existing materials from a hybrid course, hiring student assistants for video production, and utilizing undergraduate student volunteers to help on discussion boards. A total of 2119 participants enrolled in the course with 335 participants (16%) receiving a passing grade. Participants who were still actively engaged in the course by Week 2 had a much higher passing rate of 58%. Discussion boards and surveys provided feedback about the course format, participants' demographics, and participants' attitudes of the course. Most participants possessed at least a bachelor's degree, took the course primarily to enhance job-related skills, and were unaffiliated with the university. Participants' comments about the MOOC were overwhelmingly positive and the MOOC enhanced their attitudes toward the subject matter. Based on the success of this first offering, an expanded version of the MOOC was offered during Spring 2015.

Introduction

During the past few years, many universities have developed and offered massive open online courses (MOOCs) for a variety of reasons including outreach, extending access to education, promoting the university brand, increasing revenues, improving educational outcomes for both MOOC participants and on-campus students, and conducting research on innovations in teaching and learning. [1] MOOCs have the attractive characteristic of being able to reach thousands of people per offering and may play an important role in higher education in the future. Most universities do not offer official university credit through MOOCs, but participants often are eligible to receive a certificate of completion, sometimes for a small fee. [2]

The large size and online nature of MOOCs have produced a lot of data on user habits and demographics. The MOOC Project tracks many MOOCs and found that there is strong negative correlation between enrollment size and completion rate. [3] Recently the University of Pennsylvania released two studies examining the MOOCs it offered during 2012-2013. Perna et al. (2013) analyzed data from about one million users enrolled in 17 MOOCs and found the completion rate was only 4% on average. [4] Christiansen et al. (2013) looked at survey data from over 34,000 participants in 32 MOOCs and found that approximately 80% of the participants had a college degree and were

taking the courses primarily to advance in their jobs or for intellectual curiosity. [5] Low completion rates and high education levels of participants were reported by Belanger et al. (2013) for Duke University's first MOOC as well. [6]

Those studies primarily focused on participants' demographics, their reasons for enrollment, and usage patterns (e.g., number of people completing each exam) – metrics that are relatively easy to quantify. Currently, there is a lack of data regarding the impact of MOOCs on participants' learning outcomes and their effectiveness as a promotional tool for the university. This lack of data is partly due to MOOCs being a recent phenomenon; Liyanagunawardena et al. (2013) estimate that there were only 45 MOOC-related peer-reviewed articles from 2008 (the year the term "MOOC" was coined) to 2012, with most of the articles published in 2012. [7] They note that "peer-reviewed research literature on [MOOCs] is growing but still limited." More recently, Hollands and Tirthali (2014) interviewed 83 administrators, faculty members, researchers, and other people from 62 different institutions who are engaged in MOOCs or online learning. [1] They report the "actual impact on educational outcomes [on MOOC participants] has not been documented in any rigorous fashion" and it is difficult to isolate and measure the impact of MOOCs on the university brand. Hollands and Tirthali estimate the total cost of developing and delivering a typical MOOC ranges from $39,000 to $325,000 and conclude that "free, non-credit bearing MOOCs are likely to remain available only from the wealthiest institutions that can subsidize the costs from other sources of funds." They found the major cost drivers in MOOC production and delivery are the size of the production and delivery teams, video production, nature of the delivery platform, technical support for participants, creating special features such as automatic grading systems, and analysis of data.

Public primarily undergraduate institutions (PUIs), such as state universities and community colleges, typically cannot afford to invest many tens of thousands of dollars in a MOOC which does not produce easily quantifiable benefits for the institution. This effectively shuts out most public PUIs from developing their own MOOCs and prevents faculty at those institutions from gaining experience with this new style of teaching. Some state universities have partnered with private companies, such as Coursera and Udacity, to develop MOOCs. However, it is not economically beneficial for these private companies to partner with every university and the companies may prefer to partner with high-profile universities (e.g., Stanford, Georgia Tech, Princeton); most of the U.S. universities listed on Coursera's partnership webpage are not PUIs. [8] If a partnership with a public PUI is desired by a private company, compromises may have to be made regarding content and delivery methods, which may discourage the institution from agreeing to the partnership.

This paper discusses how one public PUI, California State Polytechnic University, Pomona (Cal Poly Pomona), developed and delivered a 10-week MOOC for under $10,000 – much less expensive than a typical MOOC. The MOOC was titled "Introduction to VBA/Excel Programming" and was offered during the university's Spring Quarter in 2014. The course was created in two stages over two years; the first year focused on developing material for a hybrid version of an existing course at Cal Poly Pomona, while the second year focused on repurposing that material for the MOOC. Significant savings were achieved through the following actions:

- The lead author created most of the course material including video tutorials and exams.
- Introductory videos were created by a Cal Poly Pomona undergraduate student assistant with experience in videography.
- The MOOC was hosted on CourseSites, which is a free MOOC platform by Blackboard. CourseSites offered free

technical support seven days a week as well.

- The lead author developed the course website, was the only instructor for the MOOC, and answered all emails from participants.
- Volunteer undergraduate student assistants helped answer participants' questions on discussion boards.

Pre- and post-course surveys were used to obtain demographic information, examine how participants' perceptions of the university and subject matter changed as a result of taking the MOOC, and acquire feedback about the course.

Development of a Hybrid Course

Table 1 lists the important dates in the development and delivery of the MOOC. Prior to any thought of creating a MOOC, the authors were interested in converting an existing mechanical engineering course (ME 232: Engineering Digital Computations) from a traditional lecture-only format into a hybrid format with a flipped classroom pedagogy. [9] ME 232 is an introductory computer programming course for mechanical engineering students usually taken in their first or second year. In the course, students learn the basics of Microsoft Excel spreadsheets and the fundamentals of computer programming using Visual Basic for Applications (VBA), a programming language embedded in Microsoft Office products.

During the Summer of 2012, the authors attended a week-long workshop hosted by the university's eLearning team where they learned about best practices in hybrid course design. The authors each received a stipend from the University for attending the workshop and offering the course with a hybrid format in the next academic year; the lead author has taught the hybrid version of ME 232 numerous times since Spring 2013. A comparison of student performance and perceptions in a traditional lecture-only section and a hybrid section of ME 232 can be found in the Proceedings of the 2015 ASEE PSW Conference. [10]

Although the authors developed the hybrid course prior to developing the MOOC, most of the materials were able to be repurposed for the MOOC.

Development of the MOOC

As the authors were developing the hybrid version of ME 232, MOOCs were popularized in the media with the New York Times proclaiming 2012 as the "year of the MOOC." [11] Cal Poly Pomona was interested in experimenting with this new style of instruction and it was decided to attempt a MOOC version of ME 232 titled "Introduction to VBA/Excel Programming" for the following reasons:

Table 1: Timeline of the development and implementation of the MOOC.

Summer 2012	Authors attend summer workshop on hybrid course design
Fall 2012 – Spring 2013	Hybrid version of ME 232 developed and refined
January – March, 2014	MOOC website developed on CourseSites
January 20 – April 4, 2014	MOOC participants recruited during enrollment period
March 13 – 30, 2014	Participants allowed to view website during preview phase
March 31, 2014	Week 1 officially begins
June 7-12, 2014	Final Exam period

- A computer programming course likely would attract participants with the basic computer skills necessary to take a MOOC and exam questions could be developed for automated grading. Additionally, a computer programming course likely would attract a wider range of participants compared to a more technical engineering course such as fluid mechanics.

- Excel is used in many workplaces and teaching VBA may attract a wider range of participants compared to other computer languages like MATLAB, C++, or Java.

- A complete set of video tutorials had already been created for the hybrid version of ME 232. Since video production usually is one of the major expenses in the development of MOOCs, repurposing content from ME 232 saved many thousands of dollars and hundreds of hours.

- The lead author was willing to teach the MOOC with a limited budget.

In mid-2013, Cal Poly Pomona reached out to one of the major private MOOC companies to help with the hosting and administration of the MOOC, but the company was not interested in the partnership. Faced with limited resources, it was decided to host the MOOC on CourseSites, a free MOOC platform by Blackboard. [12] The layout and functionality of CourseSites is almost identical to Blackboard Learn, the learning management system used at Cal Poly Pomona, which greatly reduced the time to become familiar with the platform. CourseSites also offered free technical support seven days a week. (Note: In 2014, Blackboard unveiled a new MOOC platform named Open Education [13] which has similar functionality to CourseSites).

Since the materials from the hybrid version of ME 232 already comprised 10 weeks of lessons, it was decided that the MOOC also would last 10 weeks and would coincide with the university's 10-week schedule of Spring Quarter 2014. MOOC participants who received a passing grade would earn a personalized certificate of completion and an online badge from the university, but official credit would not be given. Participants' scores would be based on unproctored quizzes (one per week) and an unproctored Final Exam. Although numerous online proctoring services are available, they require participants to pay an additional fee and it was decided to forego this extra feature for the first offering of the MOOC. The course syllabus provides additional information about the course and can be found in the Appendix.

The lead author was given two units of release time from a 12-unit teaching load to develop the MOOC website and recruit participants in Winter Quarter 2014. During the enrollment period, which began on January 20, 2014, participants were able to self-enroll in the course through CourseSites and were recruited through various means including:

- A story about the MOOC was featured on the university's homepage. [14]

- An email discussing the MOOC was sent to local high school students listed in a university database, as well as high school principals and guidance counselors in the surrounding area.

- The MOOC was listed at mooc-list.com and in CourseSites' catalog.

- A notice about the MOOC was placed in the university's alumni e-newsletter.

- The university's College of Engineering sent an email about the MOOC to its faculty and students.

- A notice about the MOOC was posted on the Facebook pages of the university, College of Engineering, and Mechanical Engineering Department.

The recruitment process was very time consuming for the lead author, who was primarily responsible for contacting the parties discussed above, writing the recruitment emails and notices, and responding to inquiries.

It was easier for assessment and course management purposes to end the recruitment period on Friday of Week 1 (April 4, 2014), the day after the first quiz was due. Figure 1 shows the total number of participants who joined the course during the enrollment period. There are two events that seem to have strongly impacted enrollment. First, the MOOC being featured on the university's homepage (January 22, 2014) led to a steady increase in participants during January and February. Second, there was a sharp rise in enrollment after the Week 1 content was made available at the start of the preview phase (March 13, 2014). One possibility is that participants became excited when they started the course and told friends and coworkers. Unfortunately the authors did not ask participants how they heard about the course in the surveys.

Implementation of the MOOC

Although Week 1 officially began on March 31, participants were able to access the Week 1 content and discussion boards during the preview phase beginning on March 13. On that date, an email was sent to participants welcoming them to the course and inviting them to connect to the instructor through a Facebook account created for the MOOC. Throughout the course, 262 participants (12% of those enrolled in the course) sent the instructor a friend request. The preview phase gave participants ample time to become acquainted with the course website and allowed the instructor to identify and fix technical problems. It also was hoped that participants would recruit others by word of mouth before the course officially began.

Each week was dedicated to a different topic in Excel and VBA. The week began on a Monday and ended on the following Sunday. At the beginning of the week, an email was sent to the class introducing the topic and reminding participants of important deadlines. Participants were encouraged to complete the following six tasks for each topic:

- Read the week's learning objectives and watch a brief (~1 min) introduction video. The videos provided an overview of the topic and increased the instructor's online presence.

- Watch 3-7 short video tutorials that discuss concepts related to the week's topic. Most videos were 5-10 minutes
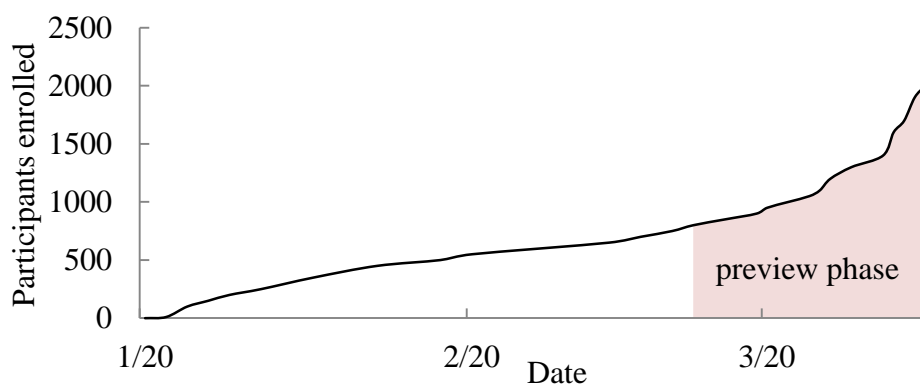

Figure 1: Number of participants enrolled in the MOOC during the enrollment period (January 20 – April 4, 2014). The shaded area corresponds to the preview phase (March 13 – April 4, 2014). A total of 2119 participants enrolled in the MOOC.

and contained closed captions for accessibility. Links to the videos were posted on the course website and hosted on the Cal Poly Pomona Mechanical Engineering Department's YouTube channel. [15]

- Complete an ungraded "sanity-check quiz" for participants to self-assess whether they understood the concepts discussed in the videos. The sanity-check quizzes were created using Blackboard's Test feature and feedback was automatically provided if participants selected incorrect answers.

- Complete an ungraded "pre-quiz" which asks participants to predict the output from a VBA program. Participants downloaded a PDF that contains a program and worked on the problem offline. After obtaining a solution, participants could check their answers using Excel.

- Complete a graded quiz that has similar content to the pre-quiz. The quiz was multiple choice, auto-graded by CourseSites, and feedback was given to participants immediately if they provided incorrect answers.

- Write VBA programs to solve 2-3 problems using concepts learned in the video tutorials. The problem statements usually included hints to help beginner students and optional extra tasks for more advanced students. The programs were not graded due to the difficulty in setting up an automated grading system, but solutions were provided at the end of the week. Class discussion boards allowed participants to receive help with their programs.

Although participants were encouraged to complete the six tasks in the order listed above, they were free to complete the tasks in any order they wished. At the end of the course, participants were allowed to take a three-hour

Final Exam any time during June 7-12. The Final Exam was similar in format to the graded quizzes.

Discussion boards were available for participants to ask questions and interact with each other. The lead author recruited five mechanical engineering student volunteers who had passed ME 232 and knew VBA well to help manage the discussion boards. Five students was quite sufficient to answer participants' questions in a timely manner since only ~10-20 participants (~0.5-1.0% of the total enrolled) posted on the discussion boards each week. Additionally, a few participants already knew some VBA and were able to answer questions as well. The lead author scanned the discussion boards daily and responded when a question required immediate attention – usually a technical question that could not be answered by student assistants – or when a participant's question was not answered within 24 hours.

The Facebook account and discussion boards were valuable tools in obtaining feedback, allowing the course structure to be adjusted to better accommodate the participants' busy lives. For example, initially participants were able to access course content for only the current and previous weeks (e.g., during Week 5, participants could access content for Weeks 1-5). However, most of the participants were working professionals and many requested that content be made available one week ahead of time (e.g., during Week 5, participants could access content for Weeks 1-6). Another example involves the graded quiz due date, which initially was on Thursdays at 10:30 PM PDT. Many participants requested that the due date be extended to Saturdays at 10:30 PM PDT to accommodate their work schedules. Both changes were easy to implement and proved to be very popular among the participants.

The lead author was responsible for the creation and maintenance of all aspects of the course website, as well as responding to participants' emails. Since both tasks required a lot of time, the lead author received four units

release time (from a 12-unit teaching load) from the university during Spring Quarter 2014.

Results – Participation Rates

It is difficult to gauge the "success" of a MOOC since attrition rates are often high. One metric uses the ratio of the number of participants who passed the course to the total number of participants who enrolled in the course,

$$R_1 = \frac{\text{\# participants passed}}{\text{\# participants enrolled}}. \qquad (1)$$

Using equation (1), typical completion rates for MOOCs are ~5-15%, with higher enrollment courses generally having lower completion rates. [3] In this MOOC, 335 participants received a passing grade, resulting in a relatively high completion rate of 15.8% (335 of 2119).

Equation (1) likely over estimates the rate of attrition because a large fraction of the participants enrolled in a MOOC never make a serious attempt to complete the course. These participants may enroll in the course to view videos without completing assignments, sign up for the course on a whim and not have time to begin the course, or forget about the course entirely. Another metric for the MOOC completion rate uses the ratio of participants who passed the course to the number of participants who took Quiz 2,

$$R_2 = \frac{\text{\# participants passed}}{\text{\# participants attempted Quiz 2}}, \qquad (2)$$

which suggests they were still actively engaged in the course through Week 2 and were serious about attempting the course. Only 582 of the 2119 participants took Quiz 2, which gives a 57.6% (335 of 582) completion rate among participants who likely were serious about the course.

MOOCs vary in duration from a couple weeks to an entire 15-week semester, making it difficult to compare completion rates among MOOCs based on equations (1) and (2) since participation tends to decline each week. Figure 2 shows participation trends in the course by examining the number of participants who accessed the website each week, attempted the weekly ungraded sanity-check quiz, and attempted the weekly graded quiz and Final Exam.
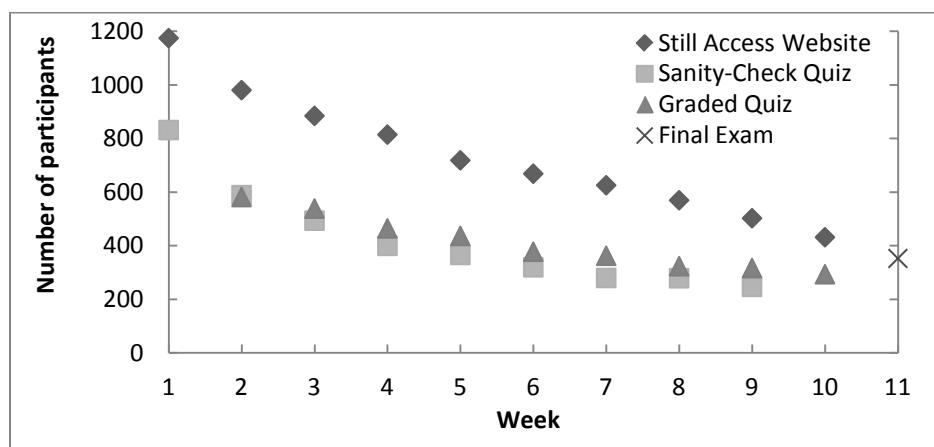

Figure 2: Weekly participation rates for the MOOC. The diamonds indicate the number of participants who had not stopped accessing the course website yet (total number of participants minus number of participants who stopped accessing the website). The squares indicate the number of participants who attempted the ungraded sanity-check quizzes that week (there was no sanity-check quiz during Week 10). The triangles indicate the number of participants who attempted the graded quizzes that week (a technical error with the MOOC platform prevented reliable data from Quiz 1). The × symbol indicates the number of participants who attempted the Final Exam.

In Figure 2, all three curves decay exponentially starting from Week 2. Other studies also have noted that participation rates in MOOCs tend to decay exponentially with time. [16-18] By fitting the Week 2-10 Graded Quiz data to an exponential curve (number still participating = $Ae^{-\lambda \cdot week}$), the decay constant $\lambda = 0.0872$ week^{-1} is obtained ($R^2 = 0.98$). This leads to a third metric of MOOC success involving the weekly attrition rate (WAR) of participants,

$$WAR = 1 - \frac{\text{\# participating next week}}{\text{\# participating current week}} =$$

$$1 - \frac{Ae^{-\lambda(week+1)}}{Ae^{-\lambda(week)}} = 1 - \frac{1}{e^{\lambda}} \qquad (3)$$

The WAR for the Graded Quiz data is 0.084, which means each week approximately 8.4% of the class stopped taking graded quizzes. Widespread use of a metric such as WAR would allow better comparison of attrition rates for MOOCs of varying duration.

Results – Surveys

Anonymous surveys approved by the university's Institutional Review Board were deployed during Week 2 (pre-course) and Week 10 (post-course) through the course website to obtain demographic data and to gauge participants' attitudes on many topics. Participants were invited via email to take the surveys and did not receive compensation for their cooperation. Each survey was available for one week, then removed from the website.

Pre-course Survey (n = 281)

The Week 2 survey focused on obtaining demographic information and getting a baseline reading of participants' attitudes. Below are highlights from that survey. Full survey results can be found in the Proceedings of the 2015 ASEE Annual Conference. [19]

- 71% of participants never enrolled in a MOOC in the past

- 70% possessed a Bachelor's degree or higher

- 67% knew at least one other computer language or attempted to learn another language in the past

- 59% enrolled in the MOOC mainly to improve skills for their job

- The age of the participants varied greatly: 0.4% were 13 or younger; 1.1% were 14-17; 22% were 18-25; 36% were 26-39; 33% were 40-59; 7.8% were 60 or older

- 12% were high school students in California

- 10% were current students, 1% were faculty or staff, 10% were alumni of Cal Poly Pomona

Post-course Survey (n = 155)

The Week 10 survey focused on obtaining feedback about the MOOC. Below are highlights from that survey. Full survey results can be found in the Proceedings of the 2015 ASEE Annual Conference. [19]

- 97% were "a little interested" or "very interested" in taking another MOOC from the university in the future.

- 94% "slightly agree" or "strongly agree" that the ungraded sanity-check quizzes were helpful in learning the course material.

- 89% "slightly agree" or "strongly agree" that making course content available one week ahead of time made it easier for them to participate in the course.

- 79% felt the video tutorials lasted "just the right amount of time."

- 59% did not use closed captions, but 26% using closed captions for over half of the videos.

- About half of the class did not use the discussion boards at all.

- Among those who used the discussion boards,

  o 76% "slightly agree" or "strongly agree" that the discussion boards helped them learn the material.

  o 75% "slightly agree" or "strongly agree" that the discussion boards created a sense of community in the course.

  o 77% "slightly agree" or "strongly agree" that their questions on the discussion boards were answered in a reasonable amount of time

  o 72% "slightly agree" or "strongly agree" that the student teaching assistants were helpful in answering their questions on the discussion boards.

Although the MOOC was developed and delivered at a relatively low cost, for school administrators to continue supporting MOOCs in the future a mechanism must exist to offset most or all of the costs. In the post-course survey, participants were asked "If Cal Poly Pomona offered another open online course in the future for a topic that interests you, and you were able to earn a Certificate of Completion and online badge for passing the course, how much money would you feel comfortable paying to enroll?" Table 2 shows that most participants would be willing to pay $11 or more to enroll in such a course, suggesting that it may be possible to offset some of the costs associated with MOOCs in the future.

Participants also were asked to provide open-ended feedback about the course, which was overwhelmingly positive. Selected comments are shown without editing.

Table 2: Amount of money participants would be willing to pay to enroll in another MOOC offered by Cal Poly Pomona for a topic that interests them

Over $40	13%
$21–40	21%
$11–20	18%
$6–10	11%
$1–5	9%
$0	28%

- "This my very first MOOC and to be honest this course and the instructor inspired me to enrolled more MOOCs without hesitation."

- "Great communication. There was never a time when I did not know what week it is, what I was supposed to be doing, and when things were due."

- "I appreciated the fact that there were closed captions."

- "The videos were very well produced, with good audio and clear video. They provided a good presentation of the material."

- "I really liked that next week content was available ahead of time. It works really well because we can plan our study better and when we feel like we are understanding the course we can move forward and not wait for the following week."

- "I'm able now to build simple modules in Excel that will be useful in my job. Thanks a lot!"

Additional comments are available in the Proceedings of the 2015 ASEE Annual Conference. [19]

Comparison of Pre-Course and Post-Course Surveys

The pre-course and post-course surveys contained a few common questions to measure how the MOOC changed participants' attitudes toward the subject matter and the university –30 participants completed both surveys. Figure 3 shows that those participants held a more favorable opinion about computer programming, Cal Poly Pomona, and engineering after taking the MOOC. However, a Wilcoxon signed-rank test indicates that only the change in participants' opinion toward computer programming was significant at the 95% confidence level.
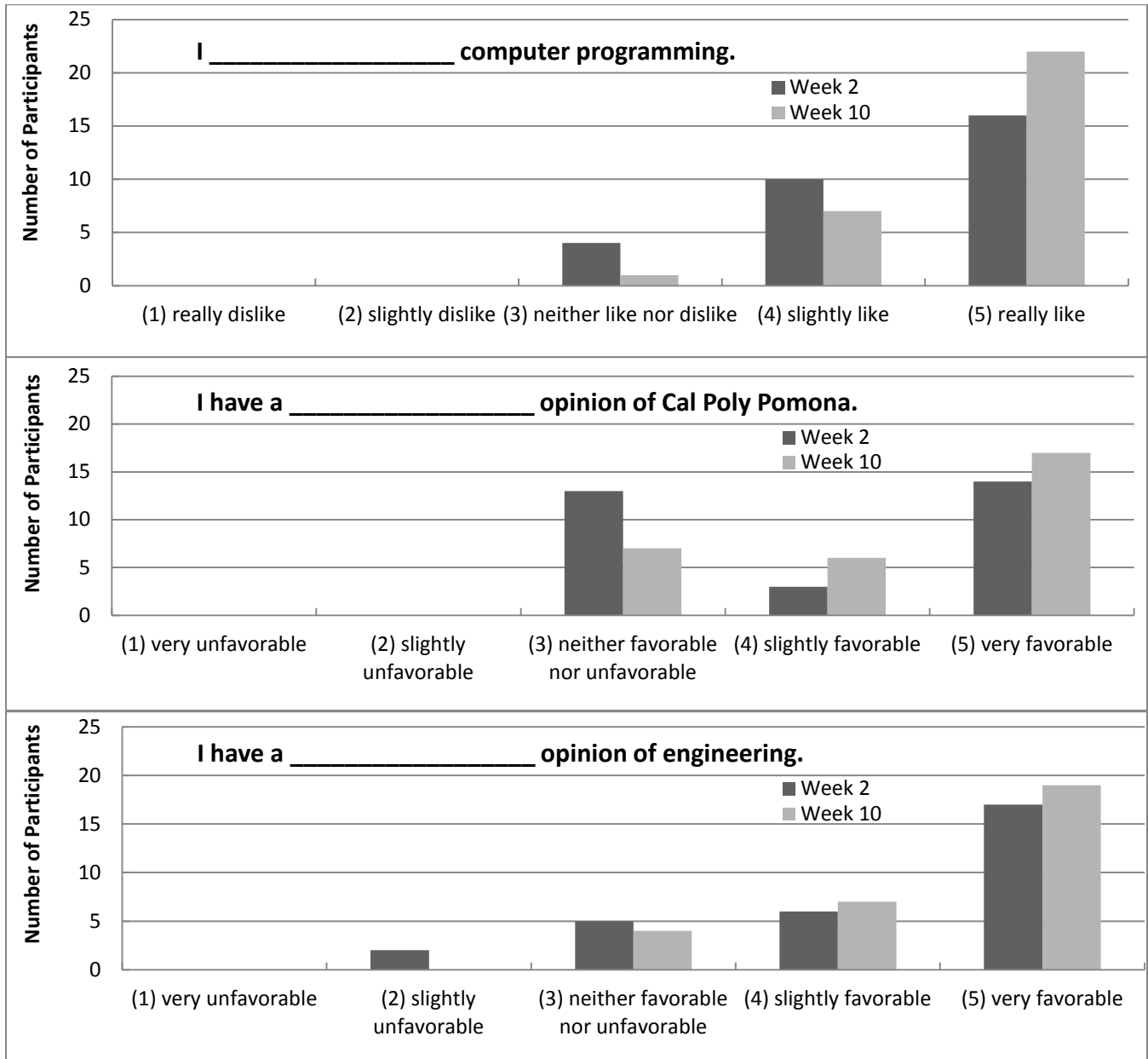

Figure 3: Comparison of participants' opinions on the pre-course and post-course surveys (n = 30). A Wilcoxon signed-rank test indicates that the only change in participants' opinion toward computer programming is significant at the 95% confidence level.

Unfortunately, only one of the 30 participants who completed both surveys was a high school student in California and it was not possible to determine whether the MOOC made Cal Poly Pomona a more attractive institution for that key demographic. Similarly, only two of the 30 participants who completed both surveys were alumni and it was not possible to determine whether the MOOC made alumni more likely to be engaged with the university.

Cost-benefit Analysis

The costs to the university related to the development and delivery of hybrid course and MOOC are listed in Table 3.

Table 3: Approximate costs related to the hybrid course and MOOC.

Stipend for authors to attend Summer 2012 workshop and develop hybrid course	$3000
Six units release time for lead author to develop and deliver MOOC	$7200
Weekly introduction videos for the MOOC created by a student assistant	$450
Miscellaneous costs for MOOC (e.g., certificate of completion design)	$300

The total cost to Cal Poly Pomona for the hybrid course and MOOC was under $11,000, with about $8,000 directly related to the MOOC. The university benefited from this project in the following ways:

- The lead author obtained first-hand experience creating and delivering a successful hybrid course and MOOC, and can be a resource for other faculty members in the future. The next section discusses many of the lessons learned by the lead author during the project.

- As discussed previously, survey results indicate that the image of the university may have been enhanced by the MOOC.

- The resources developed for the hybrid version of ME 232 and the MOOC are currently being used by students at Cal Poly Pomona. In addition, all videos used in the MOOC are available on the Cal Poly Pomona Mechanical Engineering Department's YouTube Channel, promoting the university's brand to the world. [15]

- Data on participants' demographics and performance were obtained, which could be used to help guide future outreach efforts.

- People directly related to the university benefited from the course as 11% of enrolled participants were current Cal Poly Pomona students, faculty, or staff, while 10% of the enrolled participants were alumni.

Lessons Learned

Below is general advice for anyone attempting a MOOC. The suggestions are based on the lead author's experiences teaching the course.

- Before designing the MOOC, it is critical to discuss the project with school administrators since the university's brand will be affected by the course.

- If your institution has an eLearning center with experts in hybrid and online course design, consult with them prior to creating your MOOC to ensure your course incorporates as many best practices as possible.

- Although an instructor will invest a lot of time and energy into developing and teaching a MOOC, it is important to remember that the course is just a tiny part of most participants' lives. A

completion rate of ~5-15%, using equation (1), is common.

- Certificates and online badges are very important to participants. A few participants missed the deadline for the Final Exam and failed the course. They felt devastated that they did not receive evidence of their accomplishment even though they learned the course material. Certificates should have the university name and logo, course name, student name, accomplishment, and date of accomplishment.

- Many participants are working professionals and only have time to work on the course material during the weekend. These same people appreciate being able to preview material at least one week ahead of time (e.g., During Week 5, participants can access material from Weeks 1-6).

- Some participants live in other countries and have limited English skills. Speak clearly in the video tutorials, include closed captions, and write instructions using simple phrases. Have someone else review the course materials to make sure they are easily understood by a wide audience.

- Many participants do not live in the university's time zone, so always include the time zone when listing deadlines (e.g., Thursday, April 17, at 10 PM PDT). In the course introduction, make sure to mention which time zone will be used throughout the course. It also may be helpful to include a link to a time zone converter on the course website. Even with these precautions, expect some confusion about deadlines during the first couple weeks.

- Internet connections and electrical grids are not reliable in many parts of the world. Set up quizzes and exams so that participants may re-enter them if they accidentally get disconnected. Adding some extra time for the completion of assessments also will help with these issues.

- Participants often forget to bookmark the course website. Include a link to website at the end of each email to make it easy for participants to rejoin the class.

- Allow participants to access the Week 1 material a couple weeks early to let them get used to the course format and promote the course to others. This time period also allows the instructor to correct unforeseen errors with the website before the pace of the course speeds up.

- Discussion boards can work well for MOOCs, but require constant vigilance. Consider recruiting students who are knowledgeable about the subject matter to act as volunteer student assistants in the course. The student assistants should access the discussion boards each day at different times.

- Discussion boards and Facebook can act as early warning systems. Whenever a problem occurred with the website, a few participants sent messages to the instructor immediately and he was able to correct the issue before it impacted most participants. Student assistants also alerted the instructor when they observed problems.

- In the instructions for graded assessments, include details such as the submission deadline, amount of time to take the assessment, what happens if the time runs out, what happens if participants become disconnected, which button should the participant click to submit the assignment, and the number of questions in the assessment. The instructions should be consistent week-to-week.

- Participants may mistake assessment due dates for the time when they should take the assessment. For example, if you state that participants can take a quiz at any time before Thursday at 10 PM PDT, some participants may think that they must take the quiz exactly at that time.

- Consider giving less weight to the first quiz as some participants will be confused with the course website and make small mistakes, such as accidentally submitting a quiz too early.

- Create a calendar of events section on the course website to allow participants to plan ahead.

- Give suggestions on how to prepare for the MOOC on the enrollment page. [20]

Discussion and Future Work

This paper demonstrates that it is possible for a public PUI to develop and deliver a successful MOOC for relatively low cost using local resources. For this plan to be replicated at other public PUIs, instructors must be willing to be only partially compensated for their time; the Summer 2012 workshop stipend and six units of release time received by the lead author represents a fraction of the total time put into the creation of the hybrid course and MOOC. A MOOC developed using the model discussed in this paper would have to be a "labor of love." While this may turn off many faculty members from creating their own MOOC, the lead author experienced a tremendous amount of personal satisfaction from helping hundreds of people around the world learn a new skill.

The MOOC described in this study was relatively small – only 2119 compared to the tens of thousands of participants in a typical MOOC. While many valuable lessons were learned from this project, many new issues may arise when scaling up a course by an order of magnitude. How does the interaction between participants and the instructor change? Are discussion boards still manageable? Is it necessary to have multiple instructors for course management? Is it possible to offer a much larger MOOC for a similar cost as the smaller MOOC and, if so, can a major portion of the cost be recovered through course-related fees? In order to help answer these questions, during Spring Quarter 2015 the lead author taught the same MOOC again with the goals of increasing enrollment to over 10,000 participants and recovering much of the costs. Below are some important modifications to the MOOC for the second offering.

- A Cal Poly Pomona staff member was hired to assist with the recruitment of participants.

- Release time was provided for another faculty member to assist with the administration of the course.

- A trusted undergraduate mechanical engineering student assistant helped the instructors respond to common email questions and coordinated the other student assistants to ensure adequate coverage of the discussion boards.

- A package of supplemental course materials were created and made available for purchase.

Results from the scaled-up MOOC have been submitted to the 2016 ASEE Annual Conference. [21]

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Biographical Information

Paul Nissenson is an Assistant Professor in the Department of Mechanical Engineering at California State Polytechnic University, Pomona. He teaches courses in fluid mechanics, thermodynamics, and numerical methods. His research interests are studying the impact of technology in engineering education and computer modeling of atmospheric systems. He has a Ph.D. in Mechanical and Aerospace Engineering from the University of California, Irvine.

Angela Shih is the current department chair at the Mechanical Engineering Department at Cal Poly Pomona and has served as a faculty member for over 20 years. In addition to her teaching assignments, following CPP's "Learn-by-Doing" philosophy she has worked with many students and industry partners providing practical solutions in the heat transfer/energy systems field. In the last couple years, she has been actively involved in developing smart sensors coupled with a cloud-based data acquisition system capable of monitoring and storing data real-time. She has a Ph.D. in Mechanical Engineering from the California Institute of Technology.

Appendix: Course Syllabus

Note: The syllabus format has been modified for this paper, but the content is unchanged.

Introduction to VBA/Excel Programming

Instructor
Paul Nissenson, Ph.D.
Department of Mechanical Engineering
California State Polytechnic University, Pomona

Course outline
In this 10-week course, you will develop computer programming skills using Microsoft Excel and the Visual Basic for Applications (VBA) language. These programming skills can be used to tackle a wide range of real-world problems. We will cover one topic per week.

Week 1: Introduction to the Excel workbook environment
Week 2: Introduction to the VBA Environment
Week 3: Data types & built-in functions in VBA
Week 4: Modular programming I – Sub procedures
Week 5: Modular programming II – Function procedures
Week 6: Selective execution – If structures and Select Case structures
Week 7: Repetitive execution – Loops
Week 8: UserForms
Week 9: Arrays
Week 10: Putting it all together

The Final Examination can be taken at the end of Week 10.

Prerequisites
No experience in computer programming or knowledge of engineering concepts is necessary to succeed in this course. I will assume that you know nothing about these subjects.

Software requirements
You will need the following software to participate in this course:
• For Windows, Microsoft Excel 2007 or later, Microsoft Word 2007 or later
• For Macs, Microsoft 2011 of later, Microsoft Word 2008 or later
• PDF reader – A free PDF reader is available at http://get.adobe.com/reader/

The Windows version of Excel is preferred for this course as it will be used in the video tutorials. However, you still can do well in the course using the Mac version of Excel.

No textbook is required for the course. All new material will be presented through video tutorials.

Grading
Quizzes: There will be 10 quizzes, each worth 1.5% of your overall course score.
Final Exam: There will be one exam at the end of the course that is worth 85% of overall course score.

Students receiving 50% or greater in their overall course score will receive a Certificate of Completion from Cal Poly Pomona via email. No official university credit will be given for completing this course.

Students' obligations
This is a massive open online course. Since there are many hundreds students enrolled in the course, I will not be able to interact directly with everyone. If you are having trouble understanding a concept, it is your responsibility to get help from a fellow student by using the class discussion boards as soon as possible. Although I will be reading the discussion boards frequently, I cannot promise that I will be able to personally answer your particular question. It is my hope that all of you will help each other throughout this course. Helping other students on the discussion boards also is a great way to learn the material.

Academic Integrity
Since you will be taking all tests outside of a classroom environment, I must rely on the honor system to prevent cheating. Cheating on tests is not allowed and includes using unauthorized reference materials during a test, collaborating with another person during a test, or obtaining advance copies of a test.

Online Etiquette
If a student is bullying other participants on the discussion boards, I will first give a warning to the student to terminate his or her behavior. If the student continues the bullying behavior, I will remove the student from the course. I expect that you all will be courteous to one another on the discussion boards.