# Scaling-up a MOOC at a State University in a Cost-effective Manner

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**Abstract**

Education in the world is changing rapidly. Online course offerings are increasing at an exponential rate as universities attempt to meet the needs of a diverse global community of learners. Amidst this potpourri of online courses, massive open online courses (MOOCs) are emerging as an alternative way to educate a multifarious group of learners worldwide. Yet much remains to be learned about how to hone MOOCs into cost-effective tools that provide value without overly burdening a cost-sensitive public education system. This paper provides insight into the issue by reporting on the efforts of California State Polytechnic University, Pomona (Cal Poly Pomona) to scale-up a MOOC from a small $8000 pilot project. The pilot MOOC was a 10-week introduction to computer programming course that took place during Spring 2014 and was open to everyone in the world for free. Over 2100 participants enrolled in the pilot MOOC with 16% successfully completing the course. Results from the pilot MOOC were reported in the Proceedings of the 2015 ASEE Annual Conference.

A scaled-up version of the pilot MOOC took place during Spring 2015 with the goals of increasing enrollment to over 10,000 participants and introducing cost-recovery measures while maintaining a similar budget as the pilot offering. The scaled-up MOOC was a huge success with over 11,600 participants enrolled in the course, a 16% passing rate, and recovery of about half of the costs through the sale of supplemental materials and donations. Participants who were still actively engaged in the course through Week 2 had a much higher passing rate of 55%. Additionally, surveys indicate that the MOOC enhanced participants' opinion of Cal Poly Pomona and feedback from participants was overwhelmingly positive. The paper discusses the measures taken to effectively scale-up the pilot MOOC, and provides insights and lessons learned that can be used to improve other MOOC offerings. The authors give suggestions on how to attract potential learners, minimize and recover costs, improve passing rates, and respond to participants' inquiries despite a seemingly overwhelming participant-to-instructor ratio.

## 1. Introduction

Massive open online courses (MOOCs) are a relatively recent phenomenon in higher education. The term was first used at the University of Manitoba in 2008 for a course in which 25 paying students were joined by approximately 2200 non-paying members of the general public [1, 2]. Interest in MOOCs exploded in the national media in 2011 when Stanford University attracted approximately 160,000 students for an "Introduction to Artificial Intelligence" course [3]. In 2012 the MOOC providers Coursera and Udacity were founded and began to develop and offer a variety of MOOCs. These type of courses received so much attention in the media – both positive and negative – that the New York Times proclaimed 2012 as the "Year of the MOOC" [4]. Although stories about MOOCs are much less common in the media at the time of writing, many new courses continue to be developed and offered by universities each year [5].

Reasons for developing and offering MOOCs vary. Hollands and Tirthali (2014) interviewed key stakeholders in universities that offer MOOCs and note that common reasons are 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 [6]. MOOCs typically range in size from a few thousand to over one hundred thousand participants, with many courses having many tens of thousands of participants [7]. There have been a few large studies of MOOC participation rates [7-10]. In a typical MOOC, most participants already possess at least a Bachelor's degree and take MOOCs to enhance job skills or intellectual curiosity. Completion rates (fraction of enrolled participants who pass the course) of less than 10% are common.

MOOCs can be quite costly to develop – Hollands and Tirthali (2014) estimate the cost of a typical MOOC at $39,000 to $325,000. Many public primarily undergraduate institutions (PUIs) have limited budgets and cannot afford to invest in the development of MOOCs by themselves. Although private companies such as Coursera and Udacity have at times partnered with public PUIs, it is telling that most of the U.S. universities listed on Coursera's partnership webpage are not public PUIs [11]. In order for public PUIs to participate in this new style of teaching and outreach, it is necessary for models to be created that allow these universities to develop and deliver MOOCs of their own. These models must demonstrate how a university can offer a MOOC with limited resources.

In Spring 2014, the public PUI Cal Poly Pomona developed and delivered a 10-week MOOC as a limited pilot project [12]. The title of the pilot MOOC was "Introduction to VBA/Excel Programming" and in the course participants were taught Microsoft Excel spreadsheet operations and computer programming using Visual Basic for Applications (VBA). VBA is a computer language that is embedded into all Microsoft Office products, including Excel, which makes it especially useful to a worldwide audience due to the widespread availability of Microsoft Office software.

As discussed in Nissenson & Shih (2015), the primary goal of the pilot MOOC was to gain experience in developing and administering an effective MOOC, and to obtain information on how to utilize this form of online teaching to instruct a diverse group of worldwide participants. Additional goals included extending the visibility and reputation of the university, attaining 1000-5000 enrolled participants, achieving completion rates comparable to other MOOCs (~5-10%), and doing so on a limited budget. These goals were all met as indicated by the overwhelmingly positive survey feedback, 2119 enrolled participants, and a 16% completion rate, all at a total cost of approximately $8,000 to Cal Poly Pomona. Key lessons learned from this pilot effort included the realization that for a MOOC to be a viable option for instruction and outreach within the framework of a state-funded university system, it needs to be able to attract a much larger number of participants, deliver its content to this large audience effectively, and do so in a manner that is cost-neutral to the university.

Spurred onward by the success of the pilot MOOC offering, the university reoffered the same MOOC in Spring 2015 for free with the primary goals of scaling up the MOOC to over 10,000 participants and recouping a large portion of the cost, while being allocated a similar budget as the pilot MOOC. The following enhancements were implemented in the Spring 2015 MOOC to help meet the objectives of the project.
- A second instructor was added to assist in administering the course.

- A staff member was hired to assist with the recruitment of high school students.
- More mechanical engineering student assistant volunteers were enlisted to help answer questions on the class discussion board (increased from 5 to 15).
- A trusted undergraduate mechanical engineering student was hired to help coordinate the efforts of the other student assistants and to assist with development of supplemental materials.
- A set of supplemental learning materials was made available for purchase.

The Spring 2015 MOOC was a success, meeting all goals and providing additional lessons about how to offer cost-effective MOOCs at a public PUI. In this paper, the authors provide a detailed discussion of the Spring 2015 MOOC offering, its results, and identifies lessons learned from the effort. This paper, along with Nissenson and Shih (2015), could be used by other public PUIs as a blueprint for developing and delivering their own MOOCs.

## 2. Course details

Strategic planning is a critical element to implementing a MOOC successfully and cost effectively. Key dates in the development and implementation of this MOOC are listed in Table 1. Fifteen days prior to the official start of Week 1 of the course, a "preview phase" took place allowing participants to access to the course website and to start viewing the initial lessons. The preview phase served the dual purpose of providing feedback on the materials and website, and of boosting recruitment by participants excited about the content they encountered. This preview phase appeared to have a direct impact on increasing the enrollment rate, as discussed in Section 3.

Table 1: Key dates in the development and implementation of the Spring 2015 MOOC

| | |
|---|---|
| Fall Quarter 2014 | Bb Open Education (Bb OE) contacted and the course website shell is generated. |
| Winter Quarter 2015 | Spring 2014 MOOC website is imported into Bb OE and modified. |
| Dec 21, 2014 – Apr 5, 2015 | Participants are recruited and allowed to self-enroll in the course. |
| Mar 15 – Mar 29, 2015 | Participants can access Week 1 content early during the preview phase. |
| Spring Quarter 2015 | 10-week MOOC is implemented, with Week 1 officially beginning on Mar 30. |
| June 5-13, 2015 | Participants may take the Final Exam any time during this period. |

At the start of the preview phase (March 15, 2015), participants enrolled at that time were sent an email welcoming them to the course. The email provided detailed instructions about what to expect during Week 1 and contained a link to an introductory video describing the course content. The participants were also invited to connect through a Facebook account created for the MOOC, and over 900 participants sent a friend-request during the course. The Facebook account facilitated the dissemination of important course-related information and acted as an early warning system for potential issues with the website.

The MOOC lasted 10 weeks, with a new topic discussed each week. 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 announcements. In order to allow greater flexibility in completing the course material, content was made available one week ahead of time starting with Week 2. For example, during Week 5 students would have access to content from Weeks 1-6.

Participants' scores were based on unproctored quizzes (one per week) and an unproctored Final Exam. Additional information about the course can be found in the course syllabus attached in Appendix A. The Spring 2014 pilot MOOC was hosted on Blackboard's original MOOC platform, Blackboard CourseSites [13]. In Summer 2014, Blackboard unveiled its new Open Education (Bb OE) platform, which has a similar layout and functionality as Blackboard CourseSites [14]. This made it easy to import the pilot MOOC website into Bb OE and greatly reduced the time to become familiar with the platform. Bb OE also offered technical support seven days a week.

The layout of the course website was consistent week-to-week to avoid confusion regarding learning materials and due dates. This was especially important for the many non-native English speakers in the course. Each week, participants were encouraged to complete the following six tasks:
- Read an overview of the week's topic and learning objectives, and watch a brief (~1 min) introduction video.
- Watch 3-7 short video tutorials (typically ~5-10 min each) that discuss concepts related to the week's topic. All videos contained closed captions for accessibility. Links to the videos were posted on the course website and hosted on the Mechanical Engineering Department's YouTube channel [15].
- Complete an ungraded "sanity-check quiz" for participants to self-assess whether they understand the concepts discussed in the videos. Feedback was provided automatically if participants provided incorrect answers.
- Complete an ungraded "pre-quiz" which is similar to the graded quiz. Participants could check their answers by using Excel.
- Complete a graded quiz before the due date. The quiz was multiple choice, auto-graded by the website, and feedback was given to participants if they provided incorrect answers.
- Write VBA programs to solve problem statements using the week's concepts. The programs were not graded due to the difficulty in creating an automated grading system, but solutions were provided at the end of the week.

It is important for participants to have the ability to ask questions and receive assistance in a timely manner, but it is impractical for the instructors to shoulder this massive time burden alone. Discussion boards in the Bb OE platform were utilized to provide a foundation that enabled participants to help each other at all hours of the day. This foundation was augmented by 15 undergraduate mechanical engineering student volunteers from Cal Poly Pomona who participated on the discussion boards to ensure participants' questions were being answered correctly and efficiently. A head student assistant was hired to organize the other student assistants' efforts and to make sure there was sufficient coverage on the boards throughout the

week. Most of the student assistants received no compensation for their help, although two of students were members of the university's Honors College and used their activity to meet an Honor's community service requirement. Recruitment of student assistants was easy as the MOOC content was similar to a first-year core mechanical engineering course (ME 232: Engineering Digital Computations) at Cal Poly Pomona.

The use of discussion boards to answer participants' questions seemed to work well. Most questions were answered within hours, often by other active participants. Interestingly, although 11,605 participants enrolled in the MOOC, less than 1% of the participants posted on the discussion boards each week, and the amount of posts declined as the course went on. These factors made the work of the 15 student assistants quite manageable, and it is estimated that five assistants could have easily managed the boards. Instructors also scanned the discussion boards daily, and responded to questions of a deeper or more urgent nature.

Although the use of discussion boards addressed most of the participants' questions, some participants also emailed instructors directly. This additional source of communication was managed by allowing the head student assistant to filter the emails and respond to common questions with his own judgment and with a set of standard answers provided by the instructors. This ensured instructor input was only required on the deeper or more difficult questions.

An important cost-recovery measure that was added for the Spring 2015 MOOC was the development and sale of supplemental materials, which were offered both to enhance the learning experience and to help recover some of the MOOC costs to the university. The package of supplemental materials included the following items:
- 100-page PDF containing lecture notes that cover all topics in the course
- 2-page PDF reference guide listing all the Excel VBA commands used in the course
- PDF containing all slides used in the video tutorials
- Excel files containing all the VBA code used in the video tutorials

For this MOOC, a partnership between a company called RedShelf and the university bookstore provided an eCommerce solution for managing sales. This enabled interested participants to download the materials to their local computer for a cost of $19.95. RedShelf also provided a free eReader feature that permitted purchasers to annotate the slides as well.

Based on the pilot MOOC, it was clear that participants desired evidence of their accomplishment. It was decided not to offer university credit due to the difficulties involved in ensuring academic honesty for quizzes and exams. While numerous online proctoring services are available to address this concern, using such a service would require participants to pay a fee which was expected to adversely affect enrollment. In lieu of university credit, it was decided to institute two other records of accomplishment for participants. This involved the distribution of online badges and certificates of completion to all participants who successfully passed the course. Online badges are digital representations of accomplishments which can be shared on social media websites such as LinkedIn and Facebook. The certificates of completion were designed to be attractive records of completion that could be displayed at home or in the office of a passing participant.

However, the distribution of personalized badges and certificates to potentially thousands of participants threatened to introduce another significant cost to the otherwise-lean MOOC due to the time required to create the individual records and to distribute them to participants. Therefore, a method of automatically generating and emailing the certificates was developed by the instructors using a combination of Photoshop, Excel, and VBA code. This reduced the time investment significantly, and made it possible to provide each participant completing the course with a personalized, high-quality JPEG certificate of completion and badge.

The badges were distributed to participants utilizing Bb OE's Achievements tool along with Mozilla Backpack. Participants were provided with detailed instructions on how to create a Mozilla Backpack account, transfer the badge from Bb OE into the Mozilla Backpack account, and post their badge to social networking websites.

## 3. Recruitment of participants

One of the main goals of this second MOOC offering was to attract at least 10,000 participants. The recruitment process began on December 21, 2014, over three months before the start of the MOOC, and continued through April 5, 2015. During this period participants were able to self-enroll in the course through the course enrollment page [16].

The Spring 2014 pilot MOOC demonstrated that the recruitment process can be quite time-consuming. In order to help alleviate this burden from the instructors, the Mechanical Engineering Department's Administrative Support Coordinator was hired to assist in promoting the course to California schools by sending emails to high school administrators and calling local school districts to encourage them to inform their students about the course through announcements and flyers. This promotion assistant also visited local schools to distribute flyers and responded to inquiries via email. Her efforts freed-up a significant amount of the instructors' time to work on course preparation and other avenues of recruitment. Other stakeholders in the university helped promote the MOOC in the following ways:
- A story about the MOOC was featured on the university's home page, as well as on its Facebook and Twitter accounts, in January 2015.
- A notice about the MOOC appeared in the university's weekly email announcement to faculty, staff, and students in January 2015.
- An email discussing the MOOC was sent to over 60,000 high school students listed in a university database in late January 2015 and again in late March 2015.
- An announcement about the MOOC appeared in the university's alumni e-newsletter in the February 2015.
- The university's College of Engineering posted an announcement about the MOOC on its Facebook and Twitter accounts.
- The university's Mechanical Engineering Department posted an announcement on its Facebook page.

The MOOC was promoted through external avenues in the following ways:
- The MOOC List was contacted to create a notice for the MOOC on its website [17].
- Notices about the course were posted to the online communities Reddit and Fatwallet.
- The MOOC was featured in Bb OE's MOOC catalog.

- The lead author posted announcements on a Facebook account used for the Spring 2014 pilot MOOC.
- Email announcements were sent to 83 people who signed up for an email list at the conclusion of the Spring 2014 pilot MOOC.

Recruitment ended on the last day of Week 1 to simplify assessment and course management. After that time no new participants were allowed to enroll in the course. A total of 11,605 participants enrolled during the entire recruitment period (December 21, 2014 to April 5, 2015), as shown in shown in Figure 1.
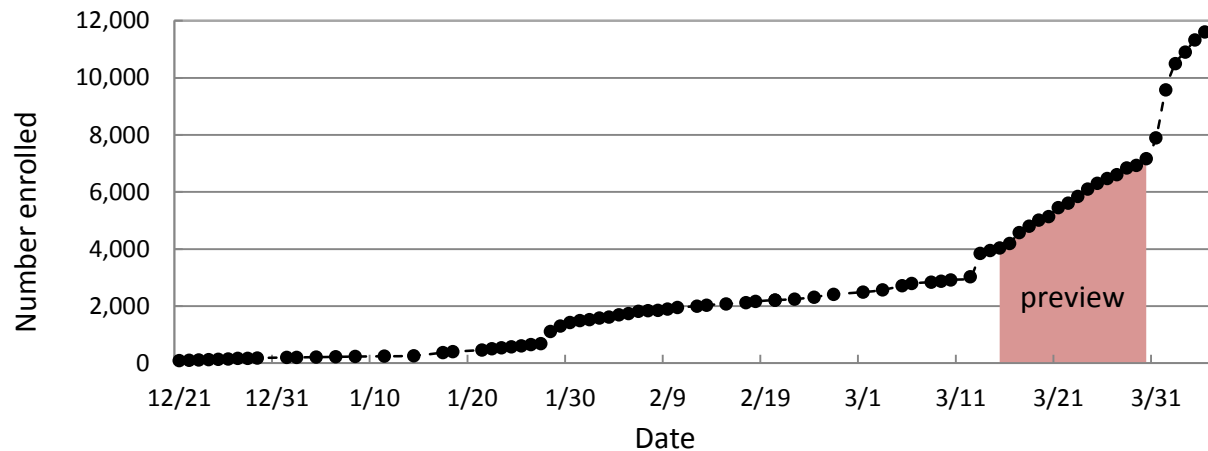


Figure 1: Total number of participants enrolled during recruitment period. Each data point represents a date that enrollment figures were recorded. The shaded region corresponds to the preview phase.

There appears to be four events that impacted enrollment strongly. Figure 1 shows three sharp increases in enrollment immediately following January 27, March 12, and March 30 which correspond to posts made by the authors on Reddit. This website has hundreds of millions of unique visitors per month and thousands of individual online communities, including many communities that would be interested in learning Excel VBA. Survey results discussed below indicate that a significant percentage of MOOC participants learned about the MOOC through this website. Enrollment rates also increased noticeably during the preview phase of the course (March 15-29, 2015) when participants were able to access the Week 1 content early. This increase may be due to enthusiastic participants who recruited co-workers, friends, or family members once they saw the quality of the course. A similar trend was observed during the preview phase in the Spring 2014 pilot MOOC as well.

## 4.1 Results – Participation rates

A total of 11,605 people enrolled in the Spring 2015 MOOC, which is over five times the number from the pilot MOOC (2119 participants) and much closer to a typical MOOC size.

Figure 2 shows participation trends in the course by examining the number of people who accessed the website each week, the number of participants who attempted the weekly graded quiz, and the number of participants who attempted the weekly ungraded sanity-check quiz. The

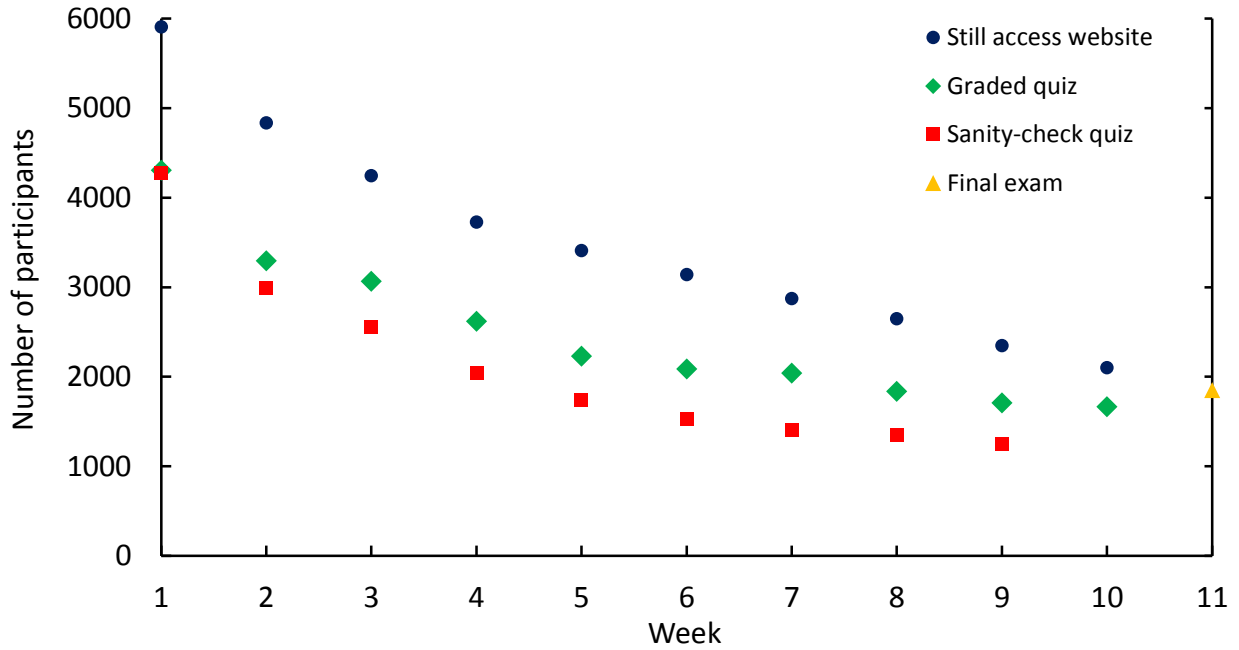participation rates decay exponentially using all three metrics, which is typical of MOOCs [12, 18-20]



Figure 2: Weekly participation rates for the MOOC. The blue circles ● 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 green diamonds ◆ indicate the number of participants who attempted the graded quizzes that week. The red 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 orange triangle ▲ indicates the number of participants who attempted the Final Exam.

There is no established metric for the "success" of a MOOC. One commonly-used metric simply uses the ratio of the number of participants who passed the course to the total number of participants who enrolled in the course,

$$R_1 = \frac{\text{total participants passed}}{\text{total participants enrolled}} \times 100\% . \tag{1}$$

Using equation (1), typically less than 10% of the participants who enroll in MOOCs offered by universities pass the course, and MOOCs with higher enrollment numbers often have lower passing rates [7, 8]. For the Spring 2015 MOOC, 1829 participants (15.8%) finished the course with a passing grade and received a certificate of completion and online badge from the university. Interestingly, both the pilot MOOC and Spring 2015 MOOC achieved 15.8% passing rates despite the five-fold increase in the number of participants.

Equation (1) likely overestimates the true attrition rate of the MOOC, since a large fraction of the enrolled participants never make a serious attempt to complete the course. These participants

may enroll in a 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 passing rate uses the ratio of participants who passed the course to the number participants who took Quiz 2, which implies they were still actively engaged in the course through Week 2 and were serious about attempting the course,

$$R_2 = \frac{\text{total participants passed}}{\text{total participants attempting Quiz 2}} \times 100\% \quad .$$
(2)

In the Spring 2015 MOOC, only 3296 of the 11,605 initial participants took Quiz 2, which suggests a 55% (1829 of 3296) passing rate among serious participants. This number is similar to the pilot MOOC's 58% passing rate using equation (2).

In Figure 2, all three curves decay exponentially starting from Week 2, similar to other MOOCs [12, 18-20]. By fitting the Week 2-10 Graded Quiz data to an exponential curve (number still participating $= Ae^{-\lambda \cdot week}$), a decay constant of $\lambda = 0.0880$ week$^{-1}$ is obtained ($R^2 = 0.96$). The decay constant can be used to calculate the weekly attrition rate (WAR) of participants, a third metric of MOOC success,

$$\text{WAR} = \frac{\text{number participating next week}}{\text{number participating current week}} = \frac{Ae^{-\lambda(week+1)}}{Ae^{-\lambda(week)}} = \frac{1}{e^\lambda} \quad .$$
(3)

The WAR calculated using the Graded Quiz data is 0.916, which means approximately 8.4% of the remaining class stops taking graded quizzes each week. The Spring 2014 pilot MOOC attained similar values of decay constant ($\lambda = 0.0880$ week$^{-1}$, $R^2 = 0.98$) and WAR (0.916). Widespread use of a metric such as WAR would allow better comparison of attrition rates for MOOCs of differing duration.

It should be noted that one possible reason for the relatively high passing rate is that it was easy to cheat on the unproctored quizzes and on the Final Exam. All questions were multiple choice and usually asked participants to predict the output of a program. To help combat dishonesty, a message was placed prominently at the beginning of every assessment that reminded participants of the importance of not cheating. However, it was not possible to know the extent of dishonesty in the course.

## 4.2 Results – Surveys

IRB-approved surveys were deployed during Week 2 and Week 10 on the course website to obtain demographic data and learn of participants' attitudes toward various aspects of the course. Participants were invited via email to take the surveys and did not receive compensation (e.g., bonus points, gifts, etc.) for their cooperation. Each survey was available for one week, then removed from the class website.

**4.2.1 Week 2 survey (n = 1335)**

The Week 2 survey focused on obtaining demographic information, as well as getting a baseline reading of participants' attitudes. Complete results from the Week 2 survey are available in Appendix B. A highlight of the responses is provided below.

- 77% of participants never enrolled in a MOOC in the past.
- 72% already knew at least one other computer language or attempted to learn another language in the past.
- 64% enrolled in the MOOC mainly to improve skills for their job, while 31% enrolled mainly for self-improvement unrelated to a job.
- 70% felt the certificate of completion and online badge was a "little important" or a "very important" factor in their decision to enroll.
- 35% learned of the course from Reddit or Fatwallet (probably mostly from Reddit based on Figure 1); 25% learned of the course through friends, family, or co-workers; 11% learned of the course through the MOOC promotion websites mooc-list.com or class-central.com; 9% learned of the course from an email or flyer from Cal Poly Pomona, or an announcement by their school or teacher; Less than 1% learned of the course through the Cal Poly Pomona website and alumni e-newsletter combined.
- The age of the participants varied greatly: 3% were 14-17 years old; 32% were 18-25 years old; 41% were 26-39 years old; 21% were 40-59; 3% were 60 or older.
- Participants lived all over the world: 23% were from California; 40% were from the rest of the United States; 10% were from other parts of the Western Hemisphere; 18% were from Europe; 3% were from Asia; 2% were from Oceania.
- 72% possessed a Bachelor's degree or higher.
- 3% were Cal Poly Pomona students; less than 1% were faculty or staff; 2% were alumni.
- 14% were high school students in California.

**4.2.2 Results – Week 10 survey (n = 571)**

The Week 10 survey focused on obtaining feedback about the MOOC. Complete results of the Week 10 survey are available in Appendix C. A highlight of the responses is provided below.

- 97% are "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.
- 60% did not use closed captions, but 19% used closed captions for 75-100% of the videos.
- 71% felt that most video tutorials were "just the right amount of time."
- 84% "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.
- Among participants who purchased the supplemental materials, 95% thought they were a "good value."
- Over half of the class did not use the discussion boards. Among those who used the discussion boards,
  - 67% "slightly agree" or "strongly agree" that the discussion boards helped them learn the material.

- 63% "slightly agree" or "strongly agree" that the discussion boards created a sense of community.
- 57% "slightly agree" or "strongly agree" that their questions on the discussion boards were answered in a reasonable amount of time.
- 56% "slightly agree" or "strongly agree" that the student assistants were helpful in answering their questions on the discussion boards.

Participants also were asked to provide open-ended feedback about the course, which was overwhelmingly positive. Selected comments can be found in Appendix C.

### 4.2.3 Results – Comparison of Week 2 and Week 10 surveys (n = 345)

A total of 345 participants took both the Week 2 and Week 10 surveys. A comparison of common questions on the Week 2 and Week 10 surveys reveals how the MOOC changed the participants' attitudes during the course. Figures 3-4 show that participants held a more favorable opinion about computer programming and the university by Week 10, but there was no significant change in their attitude toward engineering (Figure 5). Additionally, the MOOC did not make California high school and community college students more likely to enroll (Figure 6). Insufficient data was provided to determine whether the MOOC made alumni more willing to engage with the university.
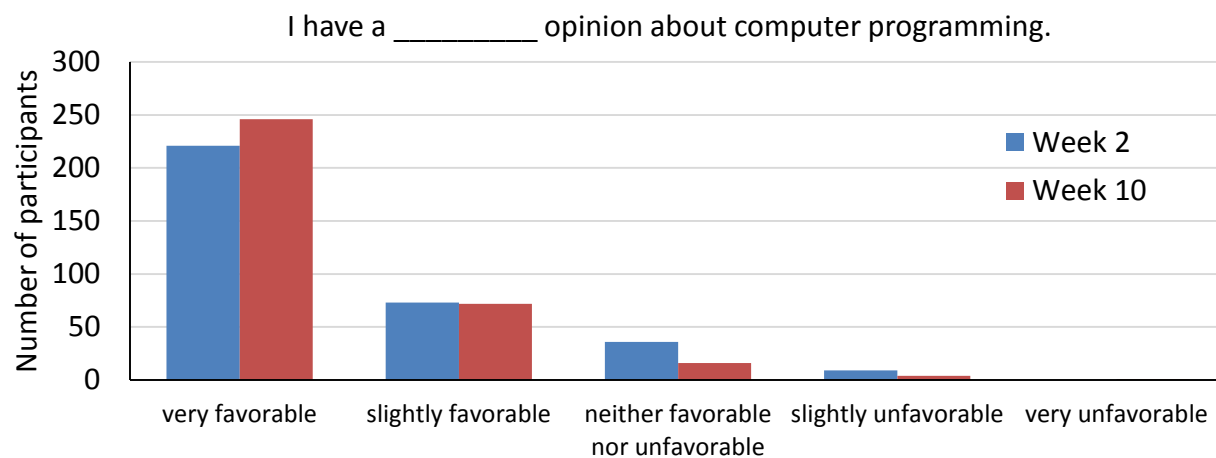


Figure 3: Change in participants' opinion about computer programming between the Week 2 and Week 10 surveys (n = 339). Assuming a five-point Likert scale with "very favorable" equal to 5 and "very unfavorable" equal to 1, the weighted average increased from 4.49 in Week 2 to 4.64 in Week 10. A Wilcoxon signed-rank test ($Z = -3.83$, $p = 0.0001$) indicates that the change in participants' opinion toward computer programming is significant at the 95% confidence level.
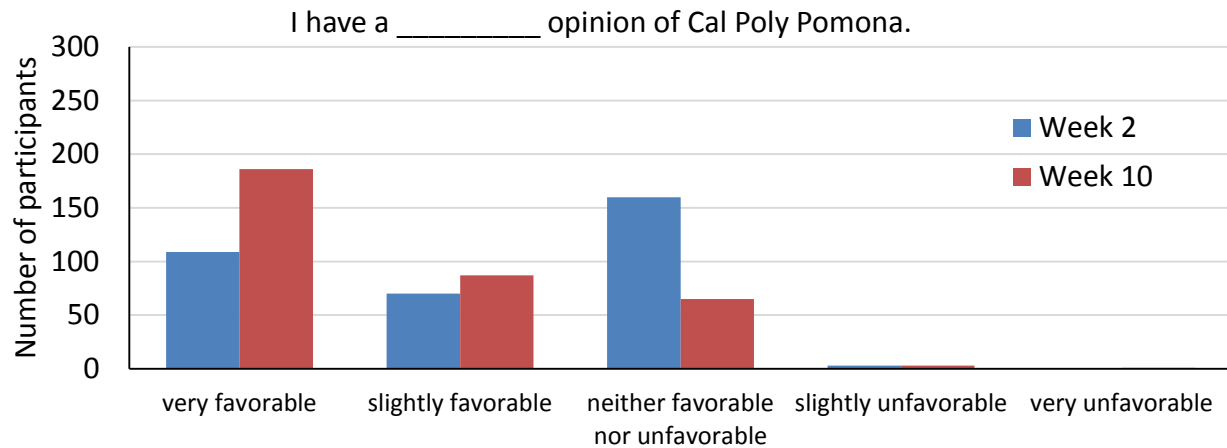
Figure 4: Change in participants' opinion about Cal Poly Pomona between the Week 2 and Week 10 surveys (n = 342). Assuming a five-point Likert scale with "very favorable" equal to 5 and "very unfavorable" equal to 1, the weighted average increased from 3.87 in Week 2 to 4.37 in Week 10. A Wilcoxon signed-rank test (Z = -8.61, p < 0.0001) indicates that the change in participants' opinion toward Cal Poly Pomona is significant at the 95% confidence level.
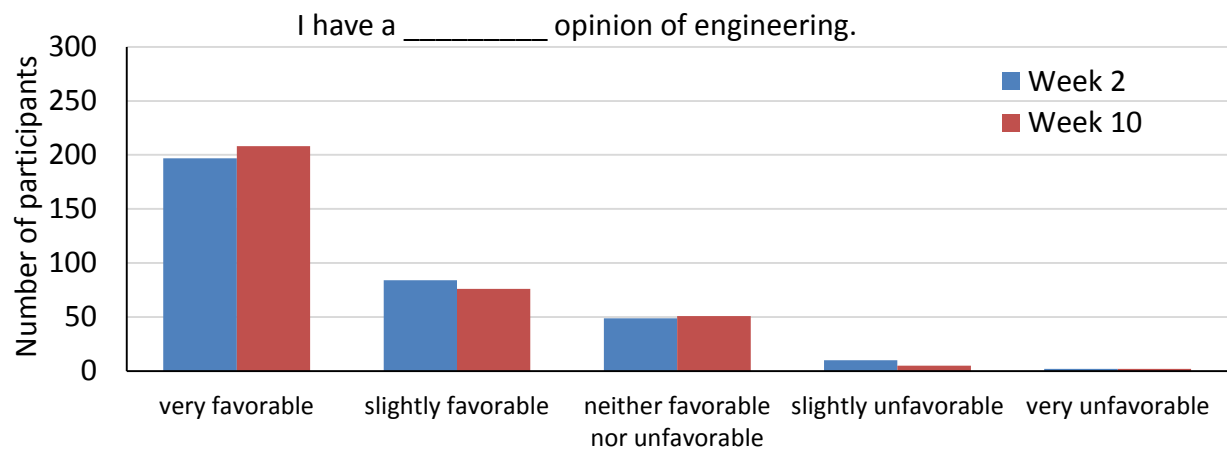


Figure 5: Change in participants' opinion about engineering between the Week 2 and Week 10 surveys (n = 342). Assuming a five-point Likert scale with "very favorable" equal to 5 and "very unfavorable" equal to 1, the weighted average increased from 4.40 in Week 2 to 4.45 in Week 10. A Wilcoxon signed-rank test (Z = -1.46, p = 0.144) indicates that the change in participants' opinion toward engineering is not significant at the 95% confidence level.
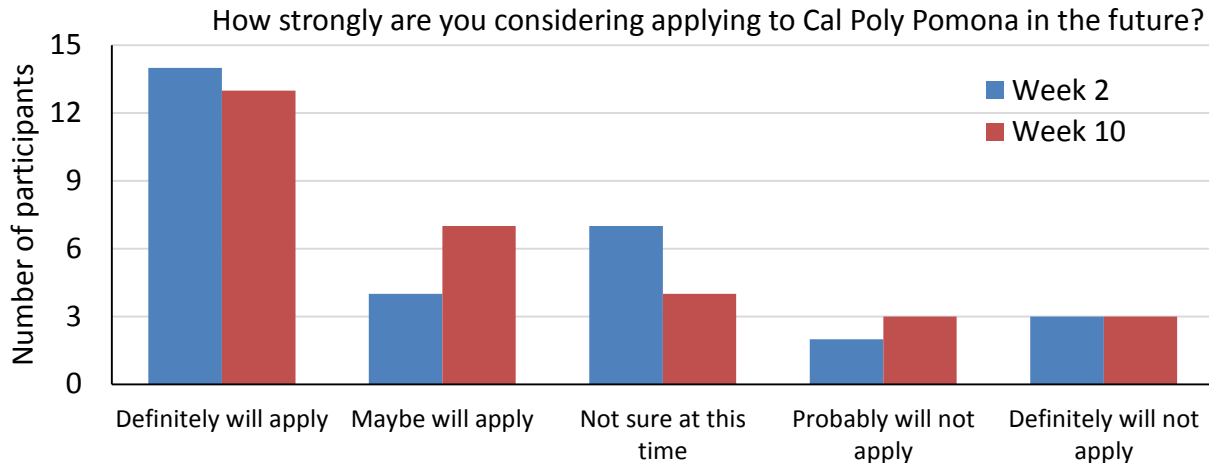
Figure 6: Change in opinion of California high school and community college students about whether they plan on applying to Cal Poly Pomona between the Week 2 and Week 10 surveys (n = 30). Assuming a five-point Likert scale with "Definitely will apply" equal to 5 and "Definitely will not apply" equal to 1, the weighted average was 3.80 for both Week 2 and Week 10. A Wilcoxon signed-rank test (T = 68) indicates that the change in participants' opinion is not significant at the 95% confidence level.

## 5. Cost-benefit analysis

The direct costs to the university are listed in Table 2. MOOCs typically cost many tens of thousands of dollars to create and implement, with the production of video tutorials being one of the most expensive and time-consuming tasks [6]. This cost was not a factor for the Spring 2015 MOOC since the video tutorials were already available from the pilot MOOC. Instead, the largest cost was release time for the authors to develop and deliver the course.

Table 2: Direct costs related to the MOOC

| Item | Approximate Cost |
| --- | --- |
| Six units release time for the authors to develop and deliver MOOC | $7200 |
| Cost for staff promoter | $1700 |
| Cost for head student assistant | $1400 |

Table 3 shows that a significant fraction of the costs were recovered through the sale of supplemental materials and donations as of August 1, 2015, a month and a half after the course ended. On August 7, 2015, the MOOC website was re-launched as a free self-paced course that requires no oversight from the instructors [16]. Enrollment is free and participants can only receive an online badge for completing the course since it would require developing a new process that automatically generates and emails certificates as participants complete the course; the process used to generate and email certificates at the end of the MOOC requires a significant amount of manual effort and is efficient only if one batch of certificates is created and emailed. New participants are still able to purchase the set of supplemental materials and it is expected that funds will slowly trickle into the university for the foreseeable future. For example, between

August 7 and December 31, 2015, 42 additional sets of materials were sold ($840 in gross sales; $670 net recovered).

Table 3: Recovered costs as of August 1, 2015

| Item | Gross sales | Net funds recovered |
|---|---|---|
| Sales of supplemental materials | $5287 | $4229* |
| Donations | $245 | $245 |

* 10% was retained by RedShelf and 10% was distributed to the university bookstore

The net cost to the university through August 1, 2015 was approximately $5800, a relatively small amount for a MOOC. The university benefited from this MOOC in the following ways:

- The authors obtained first-hand experience creating and delivering a medium-sized MOOC, and can be a resource for other faculty members who want to deliver a MOOC in the future.
- Strategies for attracting large numbers of participants and recovering a significant amount of the operating costs have been tested and proven successful.
- Survey results indicate that the image of the university was enhanced by the MOOC and participants provided many positive comments about the MOOC in the Week 10 survey (see Appendix C).
- Data on participants' demographics and performance were obtained, which could be used to help guide future outreach efforts.
- Hundreds of participants signed up for email alerts when new MOOCs are offered by Cal Poly Pomona and are a potential source of participants for future MOOCs.
- Figure 7 shows the MOOC attracted a large number of views to the Mechanical Engineering Department's YouTube Channel (CPPMechEngTutorials), where the video tutorials are still currently available [15]. Over 200,000 views occurred from the beginning of the preview phase until the end of the final exam (March 15 – June 13, 2015). In comparison, the channel only experienced about 12,000 views during the same number of days prior to March 15, 2015.
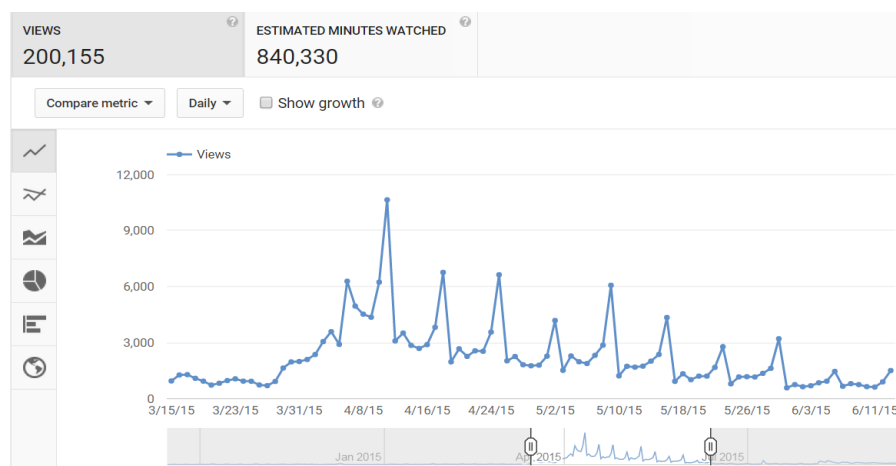


Figure 7: Screenshot of YouTube analytics data showing the total number of views on the Mechanical Engineering Department's YouTube channel during the MOOC (March 15 – June 13, 2015). In the month prior to the MOOC, the channel received only 160 views per day on average. The large spikes in viewing correspond to quiz and Final Exam due dates.

**6. Recommendations for developing a MOOC at a public PUI**

The Spring 2015 MOOC was an important step in Cal Poly Pomona's efforts to determine whether MOOCs are a viable outreach tool for the university. The authors demonstrated that it is possible to offer a medium-sized MOOC with minimal resources and can recover much of the costs through the sale of supplemental materials. The scaling-up of the MOOC from 2119 participants in Spring 2014 to 11,605 participants in Spring 2015 did not present additional major obstacles in the administration of the course – discussion boards were manageable, similar passing rates occurred, and the university's image was enhanced. Larger MOOCs would be feasible and even desirable as it could boost sales while keeping costs the same; if the number of participants were doubled in the Spring 2015 MOOC, the sale of supplemental materials likely would have doubled as well, making the MOOC almost cost-neutral. The authors recommend that any instructor who wishes to develop and deliver a MOOC strongly consider following the following steps:

- Develop video tutorials for an existing course with the idea that the videos could be repurposed for a MOOC in the future. The videos should be short, modular, and contain captions to be ADA-compliant. If the MOOC never occurs, at least the videos will benefit the local students.
- Use the video tutorials to teach a traditional face-to-face lecture, hybrid, or online course so that content and methods can be refined prior to offering the MOOC. It may be beneficial to develop, deploy, and refine the video tutorials over multiple quarters after receiving feedback from students.
- Attempt a small-scale MOOC (500-5000 participants) to get familiar with the technical aspects of offering such a course. Consider making enrollment free to attract a larger number of participants, but provide an option of purchasing a set of supplemental materials for a small fee. Do not expect the MOOC to break even, but treat it primarily as a learning experience.
- If the small-scale MOOC is successful, try expanding the MOOC by an order of magnitude (5000-50000). Since the website and course materials are already created, resources should be shifted toward recruitment.

One of the biggest challenges for future MOOCs will be recruiting sufficient numbers to recover the costs of developing and delivering the courses. MOOC platforms like Coursera and edX actively promote courses through targeted emails. Unfortunately, at the time of writing Bb OE is more passive in their promotion, electing to merely place their MOOCs in an online catalog.

If another MOOC were to be offered in the future, it would be worthwhile for the instructor and university to explore the following options to help make the course cost-neutral:

- Seek grants to pay for the development and delivery of the MOOC.
- Maintain free enrollment, but charge a small fee ($5-10) for obtaining a certificate at the end of the course. An efficient eCommerce solution would need to be developed for this idea to be viable.
- Offer a MOOC as part of a certificate program. This would boost the legitimacy of the certificate and would allow the university to charge a fee for enrolling in the course. However, an enrollment fee likely would impact enrollment numbers significantly.

- Partner with out-of-country universities, who could provide translation of videos and potentially increase the user base. However, the instructor would need to ensure the translation is accurate.

For general advice about teaching a MOOC, the reader is referred to Nissenson and Shih (2015) who provide many practical recommendations (see Section 5 and Appendix D of that paper) [12].

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**Appendix A: Course syllabus**

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

**Introduction to Excel VBA Programming**

**Instructors**
Dr. Paul Nissenson & Dr. Todd Coburn
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.

**Student learning objectives**
By the end of this course, students are expected to gain the following abilities:
- Students will be able to input data and perform basic mathematical calculations within Excel
  spreadsheets.
- Students will be able to utilize fundamental programming concepts such as variables, modular
  programming, decision structures, repetitive structures, and arrays to develop VBA programs
  that manipulate Excel spreadsheets and perform basic calculations.
- Students will be able to comprehend the purpose and logic behind simple ready-made VBA
  programs, and will be able to predict the output of such programs.

**Prerequisites**
No experience in computer programming or knowledge of engineering concepts is necessary to
succeed in this course. We 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 Excel 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 material will be presented through video tutorials and readings.

**Grading**
Quizzes: There will be 10 quizzes, each worth 5% of your overall course score.
Final Exam: There will be one exam at the end of the course that is worth 50% of overall course score.

Deadlines for each quiz and the Final Exam are listed on the course website. Students receiving 50% or greater in their overall course score will receive a personalized certificate of completion from Cal Poly Pomona via email and an online badge. No official university credit will be given for completing this course.

**Students' obligations**
If you are having trouble understanding a concept, it is your responsibility to get help on the class discussion boards as soon as possible. The instructors and Cal Poly Pomona student assistants will do their best to help everyone on the discussion boards in a timely manner.

**Academic Integrity**
Since you will be taking all tests outside of a classroom environment, we 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, we will first give a warning to the student to terminate his or her behavior. If the student continues the bullying behavior, we will remove the student from the course. We expect that you all will be courteous to one another on the discussion boards.

**Appendix B: Week 2 Survey Results**

1335 participants completed the Week 2 survey.

Have you ever enrolled in a massive open online course (MOOC) in the past?
   15.4%   Yes, and I completed at least one MOOC with a passing grade.
    6.5%   Yes, but I did not receive a passing grade in the course.
   77.2%   No, this is my first MOOC.
    0.9%   Did not answer.

Which of the following statements best describe your experience with computer programming?
   23.6%   I have some experience with writing programs in VBA.
   21.8%   I am able to write programs in at least one computer language, but do not know VBA.
   26.6%   I tried to learn at least one computer language in the past, but did not succeed in learning the
           language well.
   27.4%   I never tried to learn a computer language in the past.
    0.6%   Did not answer

Select the phrase that best represents your opinion about computer programming:
I have a _____ opinion about computer programming.
   65.8%   very favorable
   20.2%   slightly favorable
   10.7%   neither favorable nor unfavorable
    2.1%   slightly unfavorable
    0.4%   very unfavorable
    0.8%   Did not answer

Select the phrase that best represents your opinion about Cal Poly Pomona:
I have a _____ opinion of Cal Poly Pomona.
   29.7%   very favorable
   19.8%   slightly favorable
   48.4%   neither favorable nor unfavorable
    1.0%   slightly unfavorable
    0.1%   very unfavorable
    0.9%   Did not answer

Select the phrase that best represents your opinion about engineering:
I have a _____ opinion of engineering.
   53.3%   very favorable
   26.0%   slightly favorable
   17.0%   neither favorable nor unfavorable
    2.0%   slightly unfavorable
    0.7%   very unfavorable
    0.9%   Did not answer

Select the main reason why you enrolled in this course.
   64.4%   Improve skills for your job
   31.2%   Self-improvement, unrelated to your job
    0.0%   Interest in Cal Poly Pomona

| | |
|---|---|
| 1.5% | Interest in MOOCs |
| 1.0% | Other |
| 1.9% | Did not answer |

If you pass this course, you will earn a certificate of completion from Cal Poly Pomona. How important was ability to earn a certificate of completion in your decision to enroll in the course?

| | |
|---|---|
| 19.2% | Very important. If there were no certificate, I probably would not have enrolled in the course. |
| 50.9% | A little important. If there were no certificate, I probably still would have enrolled in the course. |
| 29.0% | Not important. If there were no certificate, I definitely still would have enrolled in the course. |
| 1.0% | Did not answer |

How did you learn about this course?

| | |
|---|---|
| 6.4% | Email or flyer from Cal Poly Pomona |
| 2.8% | An announcement by your school or teacher |
| 11.2% | www.mooc-list.com or www.class-central.com |
| 35.1% | www.reddit.com or www.fatwallet.com |
| 0.0% | Cal Poly Pomona website |
| 0.1% | Cal Poly Pomona alumni e-newsletter |
| 0.1% | Project Lead The Way |
| 25.2% | Friend, family member, or co-worker |
| 16.7% | Other |
| 2.2% | Did not answer |

What is your age group?

| | |
|---|---|
| 0.0% | 13 or younger |
| 2.5% | 14-17 |
| 32.1% | 18-25 |
| 40.9% | 26-39 |
| 20.8% | 40-59 |
| 2.7% | 60 or older |
| 1.0% | Did not answer |

What is the highest level of education that you have completed?

| | |
|---|---|
| 2.2% | Middle school or lower |
| 6.0% | High school |
| 19.1% | Some college (no bachelor's degree) |
| 47.3% | Bachelor's degree |
| 23.1% | Master's degree |
| 1.3% | Ph.D. |
| 1.0% | Did not answer |

From what region of the world are you taking the course?
- 23.3%    California
- 40.4%    United States (excluding California)
- 7.3%    Canada, Mexico, or Caribbean
- 2.8%    Central America or South America
- 18.1%    Europe (including Russia and U.K.)
- 3.2%    Asia (including India, Indonesia, and Philippines)
- 2.4%    Australia, New Zealand, New Guinea, Polynesia, Micronesia, or surrounding islands
- 0.4%    Middle East
- 0.7%    Africa
- 0.3%    Other
- 0.9%    Did not answer

Are you currently enrolled as a student at Cal Poly Pomona?
- 2.6%    Yes
- 95.5%    No
- 1.9%    Did not answer

Are you a faculty member or staff member working for Cal Poly Pomona?
- 0.5%    Yes
- 98.4%    No
- 1.1%    Did not answer

If you are currently attending high school or a community college in California, how strongly are you considering applying to Cal Poly Pomona in the future?
- 4.0%    Definitely will apply
- 2.6%    Maybe will apply
- 3.3%    Not sure at this time
- 1.8%    Probably will not apply
- 1.9%    Definitely will not apply
- 84.9%    I am not attending a high school or a community college in California
- 1.5%    Did not answer

Are you an alumnus/alumna of Cal Poly Pomona?
- 2.1%    Yes
- 96.4%    No
- 1.5%    Did not answer

If you are an alumnus/alumna of Cal Poly Pomona, which of the following activities do you plan to participate in during the next year? (select all that apply)
- 0.7%    Donate money and/or equipment to Cal Poly Pomona
- 1.5%    Volunteer in at least one Cal Poly Pomona sponsored program or event
- 1.0%    Attend at least one Cal Poly Pomona sponsored program or event in which you do not volunteer
- 1.2%    Be a member of the Cal Poly Pomona Alumni Association
- 94.1%    I am not an alumnus/alumna of Cal Poly Pomona
- 1.4%    Did not answer

**Appendix C: Week 10 Survey Results**

571 participants completed the Week 10 survey.

Select the phrase that best represents your opinion about computer programming:
I have a _____ opinion about computer programming.
  70.4%  very favorable
  22.6%  slightly favorable
   5.3%  neither favorable nor unfavorable
   0.9%  slightly unfavorable
   0.5%  very unfavorable
   0.4%  Did not answer

Select the phrase that best represents your opinion about Cal Poly Pomona:
I have a _____ opinion of Cal Poly Pomona.
  51.8%  very favorable
  27.0%  slightly favorable
  20.0%  neither favorable nor unfavorable
   0.5%  slightly unfavorable
   0.7%  very unfavorable
   0.0%  Did not answer

Select the phrase that best represents your opinion about engineering:
I have a _____ opinion of engineering
  55.5%  very favorable
  24.9%  slightly favorable
  17.5%  neither favorable nor unfavorable
   1.4%  slightly unfavorable
   0.7%  very unfavorable
   0.0%  Did not answer

If you are currently attending high school or a community college in California, how strongly are you considering applying to Cal Poly Pomona in the future?
   4.7%  Definitely will apply
   3.2%  Maybe will apply
   1.9%  Not sure at this time
   1.4%  Probably will not apply
   1.4%  Definitely will not apply
  87.4%  I am not attending a high school or a community college in California
   0.0%  Did not answer

If you are an alumnus/alumna of Cal Poly Pomona, which of the following activities do you plan to participate in during the next year? (select all that apply)
   0.2%  Donate money and/or equipment to Cal Poly Pomona
   0.4%  Volunteer in at least one Cal Poly Pomona sponsored program or event
          Attend at least one Cal Poly Pomona sponsored program or event in which you do not
   0.7%  volunteer
   0.7%  Be a member of the Cal Poly Pomona Alumni Association
  94.7%  I am not an alumnus/alumna of Cal Poly Pomona
   3.3%  Did not answer

Based on your experience with this massive open online course (MOOC), how interested are you in taking another MOOC from Cal Poly Pomona in the future?

- 73.4   Very interested
- 23.6   A little interested
- 1.4   Not very interested
- 1.1   Not at all interested
- 0.5   Did not answer

What is your opinion about the following statement:
The ungraded sanity-check quizzes were helpful in learning the course material.

- 71.5%   Strongly agree
- 22.9%   Slightly agree
- 4.4%   Neither agree nor disagree
- 0.5%   Slightly disagree
- 0.4%   Strongly disagree
- 0.4%   Did not answer

During what percentage of the video tutorials did you use closed captions?

- 60.4%   0%
- 8.1%   1-24%
- 7.2%   25-49%
- 5.1%   50-74%
- 18.6%   75-100%
- 0.7%   Did not answer

Select the phrase the best represents your opinion about the length of the video tutorials:
Most video tutorials were _____.

- 2.5%   way too long
- 21.4%   a little long
- 70.6%   just the right amount of time
- 4.7%   a little short
- 0.2%   way too short
- 0.7%   Did not answer

What is your opinion about the following statement:
The online discussion board helped me learn the material.

- 12.1%   Strongly agree
- 15.8%   Slightly agree
- 10.7%   Neither agree nor disagree
- 2.6%   Slightly disagree
- 0.7%   Strongly disagree
- 57.8%   I did not use the discussion boards
- 0.4%   Did not answer

What is your opinion about the following statement:
The online discussion boards created a sense of community in the course.
    12.3%    Strongly agree
    14.4%    Slightly agree
    13.8%    Neither agree nor disagree
     1.2%    Slightly disagree
     0.5%    Strongly disagree
    56.7%    I did not use the discussion boards
     1.1%    Did not answer

What is your opinion about the following statement:
My questions on the discussion boards were answered in a reasonable amount of time.
    12.1%    Strongly agree
     4.9%    Slightly agree
    10.9%    Neither agree nor disagree
     1.4%    Slightly disagree
     0.5%    Strongly disagree
    69.4%    I did not use the discussion boards
     0.9%    Did not answer

What is your opinion about the following statement:
The student teaching assistants were helpful in answering my questions on the discussion boards.
    10.7%    Strongly agree
     6.0%    Slightly agree
    12.1%    Neither agree nor disagree
     0.7%    Slightly disagree
     0.4%    Strongly disagree
    69.5%    I did not use the discussion boards
     0.7%    Did not answer

During the course, content was available one week ahead of time. For example, you could view Week 7
content during Week 6. What is your opinion about the following statement:
Making course content available one week ahead of time made it easier for me to participate in the
course.
    67.8%    Strongly agree
    16.6%    Slightly agree
    13.1%    Neither agree nor disagree
     0.7%    Slightly disagree
     1.1%    Strongly disagree
     0.7%    Did not answer

If you purchased the supplemental materials (lecture notes, quick reference guide, PowerPoint slides, and
VBA code) on the "Support CPP MOOCs" section of the website, do you feel the materials were a good
value?
    15.6%    Yes, the supplemental materials were a good value
     0.9%    No, the supplemental materials were not a good value
    83.0%    I did not purchase the supplemental materials.
     0.5%    Did not answer

The comments from participants, which were overwhelmingly positive, are too numerous to list in this document. Below are selected comments from students, with minor editing to fix grammatical errors. The full list of comments is available upon request.

What did you like about the course and/or instructor?

- "Great pronunciation and pausing for non-English speaking audience, along with the close[d] caption it was excellent. I know how hard it is to explain difficult material, and here without the immediate feedback from students it must have been harder. I like a lot the course, in just 10 weeks covered all ma[j]or points. I really appreciate what you guys are doing at Pomona. I hadn't heard about you but now I have a great opinion about you."
- "The course was well structured. The online videos were well produced. While some of the concepts were difficult, the presentations were in plain language and relatively eas[y] to understand. I encourage anyone interested in learning VBA to take this course."
- "[The instructors] did a fantastic job explaining the course material in a way that was easy to follow and understand. The topics covered were exactly what I needed to learn and provided me with the confidence to know that with some time and effort I really can create my own macros and simplify some of my day to day tasks. VBA isn't scary to me anymore. I was a bit skeptical of this course given that it was free and online, but I have to say that this course and the instructor far surpassed my expectations. The supplemental material is a great resource to have (in particular the last document that was added, with the lecture notes as opposed to just powerpoint slides). I would love to see a part 2 or advanced course that builds on the foundation learned in this course! Thank you, thank you, thank you for providing this course!!!"
- "The course took something as complex as coding and broke it down to an easy-to-understand set of weekly modules that fit my schedule. I really liked how it was designed to be at a student's pace. The professor seems very knowledgeable about the course material and explained it in a way that made me, a non-engineering student, be able to understand it."


What did you dislike about the course and/or instructor?

- "Talked a little slow. I usually increased speed of videos. Also, I didn't like that quizzes were due on Saturday night. Making them due on Sunday would be much more helpful, as many have time available on Sunday more than Saturday."
- "The course mostly took place during the school year, making it more difficult for me to keep up with the online class alongside my regular schoolwork."
- "A couple more examples could be useful as an extra video in each lesson. Make the [homework] mandatory."
- "I would have liked it if the course and instructor had the resources to go into depth about objects, classes, libraries, setters, getters, api's, etc. It would be nice to know if this course were made into a series; part2, part3, etc."