

Characterizing Video Use in the Catalogue of MITx MOOCs

Authors

Daniel T. Seaton
dseaton@mit.edu

Sergiy Nesterko
sergiy_nesterko@harvard.edu

Tommy Mullaney
tmullaney@college.harvard.edu

Justin Reich
justin_reich@harvard.edu

Andrew Ho
Andrew_Ho@gse.harvard.edu

Graduate School of Education -
Harvard University
USA

Lecture videos intended to substitute or parallel the on-campus experience are a central component of nearly all current Massive Open Online Courses (MOOCs). Recent analysis of resources used in the inaugural course from MITx (6.002x: Circuits and Electronics) revealed that only half of all certificate earners watched more than half the available lecture videos (Breslow et al. 2013, Seaton et al. 2014), with the distribution of videos accessed by certificate earners being distinctly bimodal. This study shows that bimodal lecture-video use by certificate earners persists in repeated offerings of 6.002x, with the distribution of video accesses being nearly indistinguishable. However, there are generally two modes of video use spanning the catalogue of MITx courses: bimodal and high use, both characterized via analysis of the distribution of unique videos accessed in each course. For both modes of video use, country-of-origin significantly impacts the measurement of video accesses. In addition, preliminary results explore how course structure impacts overall video consumption across courses.

Tags

massive open online course,
MOOC, learning analytics,
videos, video use, online
learning, distance education

Introduction

Short videos interspersed with assessment items are a central feature in nearly all Massive Open Online Courses (MOOCs). This course component enables instructor-participant interaction in the absence of traditional on-campus lecture. Video length and the frequency of assessment items are intended to increase student engagement, and recent research suggests that the general format of short videos provides learning outcomes comparable to traditional on-campus lectures (Glance, Forsey, & Riley, 2013). Research aside, such video formats have proven to be quite popular in a number of non-traditional education settings, e.g., Khan Academy, implying the possibility of a lasting trend. In order to begin the process of measuring overall impact of videos in MOOCs, an analytics baseline must be established for participant-video interactions.

MITx, the Massachusetts Institute of Technology's MOOC division, releases MOOCs through the edX platform (www.edx.org), offering participants a digitized set of course components motivated by both MIT on-campus activities and best practices in digital learning. Although variation in course components exists between courses, lecture videos are present within all MITx MOOCs. Each course is divided into weekly units (or chapters) containing approximately two learning sequences, typically made up of a number of short videos interspersed with content-engaging questions. The format of individual lecture videos differs, ranging from filmed MIT on-campus lectures modularized into short segments, to tablet recordings of instructors appending PowerPoint slides. Although consistently delivered in regard to interface, the total number of lecture videos, their length, and the frequency of lecture questions vary from course to course.

This work was initiated by a finding in the analysis of the inaugural MITx course 6.002x: Circuits and Electronic, namely, a bimodal distribution of unique lecture-videos accessed by certificate earners (Breslow et al. 2013, Seaton et al. 2013), namely, half of the 6.002x certificate earners accessed less than half of the lecture videos. These same certificate earners completed nearly all graded assignments for homework and the online laboratory, but chose not to use many of the supplementary learning components like the textbook and wiki. A number of questions emerge from this observation: Are bimodal video accesses a standard phenomenon in MOOCs? Is this simply an effect of Internet access? Are course features impacting video use? How are learners making decisions about which resources to use? In terms of video use, the 6.002x finding is supported by on-campus analysis of student interactions with online videos: medical school students provided with lecture recordings were found to have mixed usage and varying levels of impact on performance (Romanov & Nevgi, 2007, McNulty, et al., 2009).

The current study seeks to understand the most basic features of video use in MITx courses: unique accesses by participants and variation among courses. The distribution of unique video accesses provides a means of analyzing overall use by course participants; in this case, certificate earners. Metrics ranging from mean videos watched, to Beta function modeling, allow for comparison across courses, as well as for repeated offerings of the same course. As a first step, video accesses in the inaugural 6.002x course are compared against two repeated offerings in

which content changes were minimal, revealing remarkable similarity between all three courses. Gained insight is applied to the remainder of the MITx course catalogue, revealing courses whose overall accesses moves into a category of high use. For the entirety of the MITx course catalogue, country-of-origin is shown to be an important factor when analyzing video accesses. Finally, preliminary work explores the impact of course structure (design of lecture sequences) on course-wide video accesses.

Courses and Participants

MITx Massive Open Online Courses (MOOCs) are delivered through the edX platform, with the intention that anyone with an Internet connection can enroll and interact with course content. A typical MITx course aims to recreate the on-campus experience at MIT by providing participants with a number of digital course components: lecture videos, lecture questions (short questions interspersed in lecture videos), homework, an eTextbook, student and instructor edited Wiki, and a discussion forum. Although these components represent the core of a MITx course, instructors have freedom to add supplementary components such as online laboratories (e.g., the 6.002x Circuit Sandbox used to construct and test simple circuits or the 8.02x TEAL visualizations used to model phenomenon in Electricity and Magnetism). Analysis of resource use in the inaugural 6.002x has shown certificate earners utilized course components in terms of overall time spent and unique resource accesses (Seaton et al. 2013).

Course	Description	Certificates Earned	Number of Lecture Videos	Number of Lecture Questions	Mean Video Length
Spring 2012					
6.002x	Circuits and Electronics	7157	416	109	5.5 min
Fall 2012					
3.091x	Solid-State Chemistry	2061	171	120	6.5 min
6.00x	Intro. To Programming	5761	153	158	8.2 min
6.002x	Circuits and Electronics	2995	416	109	5.5 min
Spring 2013					
2.01x	Elements and Structures (not analyzed)	*	*	*	*
3.091x	Solid-State Chemistry	547	242	163	6.2 min
6.00x	Intro. To Programming	3313	150	153	8.1 min
6.002x	Circuits and Electronics	1101	416	109	5.5 min
7.00x	Intro. Biology	2332	142	128	11.9 min
8.02x	Intro. Physics: Electricity and Magnetism	1720	267	229	6.8 min
14.73x	Global Poverty	4608	158	156	7.6 min

Table 1: The MITx catalogue through Spring 2013 is listed in Table 1, providing labels and short descriptions of each course, along with the number of certificates granted, total number of lecture videos, total number of lecture questions, and mean lecture video length.

Although any combination of course components can form the structure of a MITx course, lecture videos are central component within all MITx courses. Each course is divided into weekly units of course work (chapters) containing one to two learning sequences consisting of a number of short videos with interspersed questions. As discussed in the introduction, the format of individual lecture videos can differ, but delivery is consistent across courses. Table 1 contains course information relevant to this study for the MITx course catalogue through Spring 2013. The course names will be an important reference throughout this work. Archived versions of most courses can be accessed via edX (www.edx.org).

MITx courses have been host to massive enrollments as evidenced in Table 1 (total enrollments are often ten times the size of certificate earning populations). These enrollments have varied greatly in terms of their cultural and educational backgrounds, as well as overall level of participation. The impact of diversity on resource use can be found in initial analyses of 6.002x (DeBoer et al., 2013), as well as in terms of performance and participation in 8.02x (Rayyan, Seaton, Belcher, Pritchard, & Chuang, 2013).

Methods

Current technology streamlines the collection of records on participants and their activities within a given MOOC, providing detailed data for a “massive”, and equally diverse, set of participants. A recent report has shown participation varies greatly in MOOCs (Kizilcec, Piech, and Schneider, 2013), e.g., some participants only watch videos, while others complete assignments asynchronous to course due dates. In the case of the inaugural 6.002x course, time spent measures indicate some participants simply take exams (Seaton, et al., 2013). Until future analyses can more generally classify participant-strategies, certification status provides a first-pass filter for those participants likely to interact with the majority of course content relative to due dates ((Seaton, et al., 2013) provides further justification based on time-on-task). Hence, lecture-video accesses are reported here only for participants having earned a certificate. Sample sizes for certificate earners in each course are listed in Table 1.

This study is centered on analyzing the distribution of lecture-video accesses for certificate earners in a given edX course. Click-stream data contain records of all participant-video interactions (pause, play, or loading of a video) and their associated IDs.

Other data are also stored within the click-stream, including timestamps, video speed, and participant IP address, but participant ID and video ID are the only fields required to estimate number of unique videos accessed by each participant. After calculating the number of unique lecture-video accesses per certificate earner, overall distributions can be generated for each course. Fraction of lecture videos accesses provides a simple transformation allowing for cross-course comparison.

As stated previously, videos as a resource type serve a number of purposes in MITx courses: “Problem Solving Tutorials”, “Welcome or Introduction”, etc. Course structure data can be extracted to link each video with a specific course component. Hence, this study focuses only on video interactions classified as “Lecture Videos”, or those representing the principal learning sequences found in each chapter (week) of a MITx course.

Plotting distributions of the fraction of unique videos accessed is a first step in understanding video use, but in addition, one can model such distributions using functions with support on the interval $[0,1]$. Beta functions provide a two-parameter model capable of accounting for floor and ceiling effects associated with the finite interval. Plotting resultant fitting parameters in a simple two-parameter space provides insight into the mean number of videos watched and the shape of each distribution. These modeling techniques have been effective in analyzing the impact of course structure on eText use in both on-campus (Blended, Flipped) and online (Distance, MOOC) settings (Seaton, Bergner, & Pritchard, 2013); although a closely related two-parameter model was employed. Beta functions also provide other unique applications in education research (Smithson & Verkuilen, 2006). All applications of Beta functions in this work have been carried out via statistical libraries in Python (Scipy.Stats).

Figure 1 contains three methods used to scaffold visualizations used in this study: PDF - Probability Distributions (Left), CCDF - Complementary Cumulative Distributions (Middle), and (a,b) - Beta Parameters (Right). PDFs provide a familiar way of analyzing distributions (histograms), while CCDFs allow one to more easily visualize many distributions in a single figure. The measured variable X represents the fraction of accessed videos. Five exemplary PDFs (Left) are plotted and labeled by the Beta Parameters used to simulate them. The two solid curves have identical means but quite distinct shapes: one unimodal (normal) distribution ($a=b=4.0$), and one bimodal distribution ($a=b=0.5$). Other example PDFs represent commonly encountered

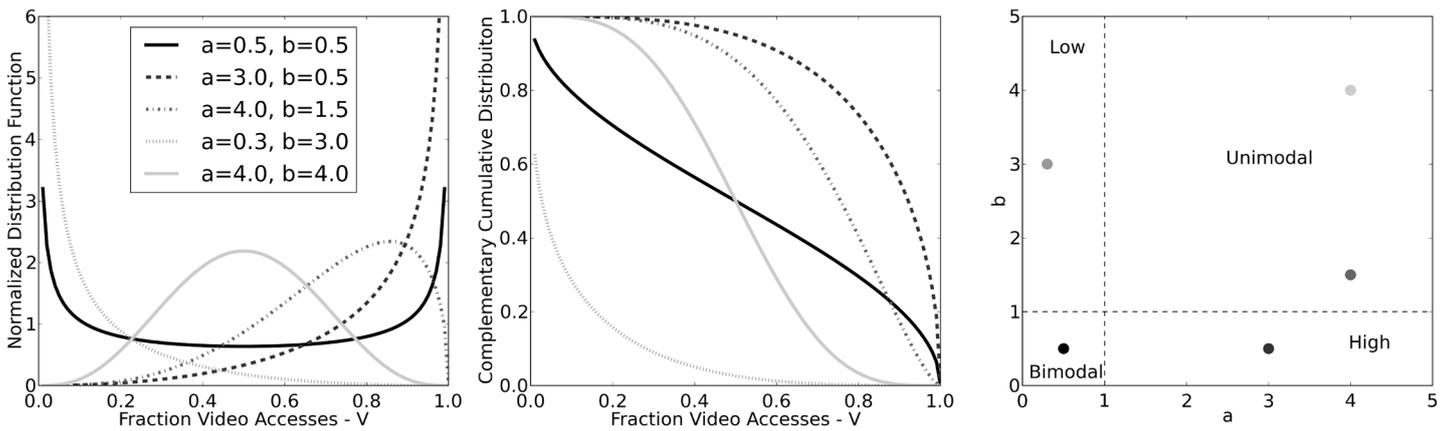


Figure 1. Example distributions for the fraction of videos accessed (left) generated using Beta functions whose parameters are given in the legend. These distributions can be transformed into Complementary Cumulative Distributions such that features are more easily viewed in a single graph. Beta function fitting parameters can also be plotted (right) to help classify use. Regions are marked as low, high, bimodal, and unimodal.

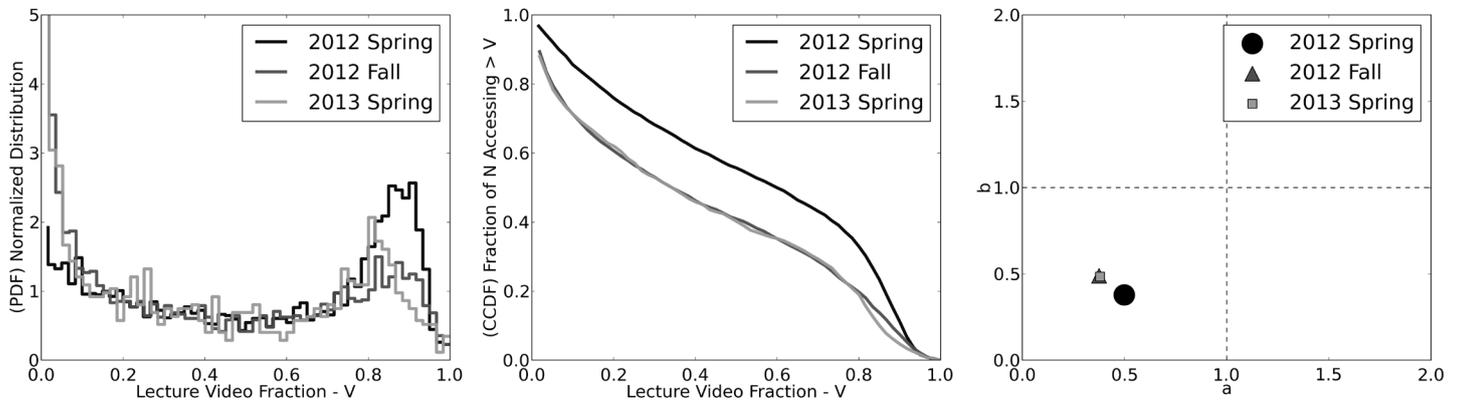


Figure 2. Fraction of videos accessed by certificate earners in repeated offerings of 6.002x plotted as Normalized Distributions (Left), Complementary Cumulative Distributions (Middle), and as resultant Beta Parameters (a,b) from fitting analysis (Right). Symbol sizes for Beta Parameters are proportional to the number of certificate earners.

distributions. CCDFs (Middle) are plotted for the same PDFs, where CCDFs weighted toward $X=1.0$ appear in the upper-right quadrant ($a=3, b=0.5$), and distributions weighted toward $X=0.0$ appear in the lower-left quadrant ($a=0.3, b=3.0$). Bimodal and unimodal distributions traverse the middle of the graph. Beta Parameters (Right) offer an even clearer representation of each distribution. Four relevant regions containing similarly shaped distributions are separated by dashed lines: bimodal ($a, b < 1$), low usage ($a < 1, b > 1$), high usage ($a > 1, b < 1$), and unimodal ($a, b > 1$). Within the unimodal region, the proximity of (a, b) to the low and high usage implies a distribution mean shifted toward low or high usage. Beta Parameters provide a framework for classifying usage distributions and are an important aspect of this work.

Results

Persistence of Bimodal Video Use in 6.002x and the Impact of Downloads

The first major goal of this study addresses whether bimodal video accesses persist in repeated offerings of 6.002x. Figure 2 highlights the distribution of video accesses by certificate earners in all three offerings via our described visualization methods. Both the PDFs (Left) and the CCDFs (Middle) show that all three offerings have the same general bimodal shape, but that the inaugural course (2012 Spring) had slightly higher overall video consumption compared to repeated offerings (2012 Fall, 2013 Spring). Again, minimal changes were made to 6.002x content in repeated offerings of the course. Similarity in the shape of the three distributions indicates consistent behavior in how participants interact with course resources. Population sizes (number of certificate earners) can be found in Table 1; symbol sizes for Beta parameters reflect relative population sizes.

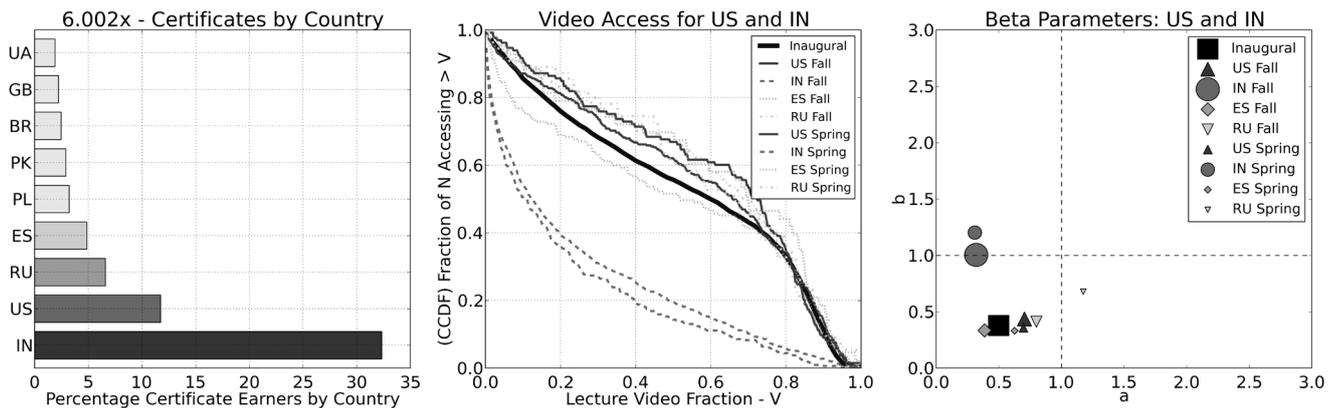


Figure 3. Percentage of certificates earned by country-of-origin (Left) for the Fall 2012 and Spring 2013 repeated offerings of 6.002x (note, metrics currently not available for the inaugural course). CCDFs (Middle) and Beta Parameters (Right) highlight the differences in video access distributions via the top four certificate earning countries. Symbol size is proportional to sample size.

Regarding the gap between distributions for the inaugural and repeated offerings of 6.002x, one glaring explanation stems from the addition of the “download video” option added to courses starting in Fall 2012 (inaugural course had no download option). Supporting that possibility is the striking overlap visible in both the CCDFs (Middle) and Beta Parameters (Right) for the Fall 2012 and Spring 2013 courses. In order to account for downloading, video accesses are explored through the lens of country-of-origin (provided via IP country look-up). The hypothesis is two-fold: one, if downloaders can be accounted for, the distribution of video access for repeated 6.002x courses will overlap the inaugural course, and two, country-of-origin provides a proxy for downloading due to potentially poor internet access.

Here, this hypothesis is explored by separating video-access distributions by country-of-origin for the Fall 2012 and Spring 2013 6.002x courses (Figure 3), where the top-four countries for certificates earned in 6.002x Fall 2012 and Spring 2013 (Left) are the United States, India, Russia, and Spain (IP analysis providing country look-up has not been performed for the inaugural course, but may in the future). Separating each video access distribution by country allows for the comparison of country-level data with the inaugural course. CCDFs (Middle) show interesting trends: India has substantially lower video consumption relative to the inaugural course (thick black line), while other countries are close in proximity to the inaugural course. The Beta Parameters (Right) also indicate the differences in video consumption by country. India distributions border bimodal and low use, while all others maintain bimodality, with the exception of Russia in the Spring 2013 course. Although not confirmatory, these results highlight a possible download effect, but at minimum, show that country effects are an important aspect of analyzing resource use.

Video Consumption Across All MITx Courses

Of equal interest is the comparison of video accesses across courses. In Figure 4 CCDFs are plotted for all courses delivered in the Fall 2012 (Left) and Spring 2013 (Middle) cycles, along with Beta Parameters for courses from both cycles (Right). CCDFs for Fall 2012 (Left) highlight video consumption in two newly introduced MITx courses: 3.091x, which is bimodal, and 6.00x, which represents high rate of video accesses (6.002x is plotted as a reference).

All of the Fall 2012 courses were repeated in the Spring 2013 with minimal edits to content. The CCDFs for these courses are plotted as dashed lines in the Spring 2013 cycle (Middle Figure 4), while three newly introduced courses are plotted as solid lines (7.00x, 8.02x, 14.73x). The CCDFs for the Spring 2013 cycle show a clear distinction between courses with high video consumption and the two courses with bimodal use, 3.091x and 6.002x. At first glance, all new courses in the Spring 2013 cycle appear to be high consumption, but the Beta Parameters tell a slightly different story. 8.02x appears within the bimodal region, indicating a significant tail toward low video consumption (notice the slight inflection (convex) over the interval [0.0,0.6] in the CCDF). Results from Fig. 4 highlight two distinct modes of lecture video consumption: bimodal and high use. Such access rates for videos stand in contrast to the overall access of eText resources in MOOCs, which were found to be primarily low use resources within selected MITx courses (Seaton, Bergner, & Pritchard, 2013).

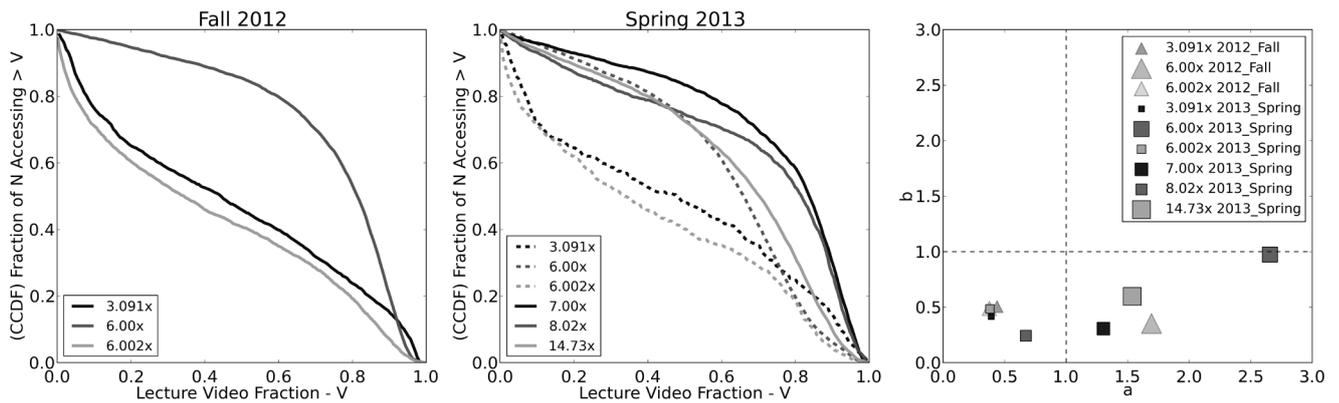


Figure 4. Fraction of videos accessed by certificate earners in all MITx courses from Fall 2012 (Left) and Spring 2013 (Middle). Beta Parameters (Right) indicate the overall shape of each distribution. Symbol sizes are again proportional to the number of certificate earners in each course.

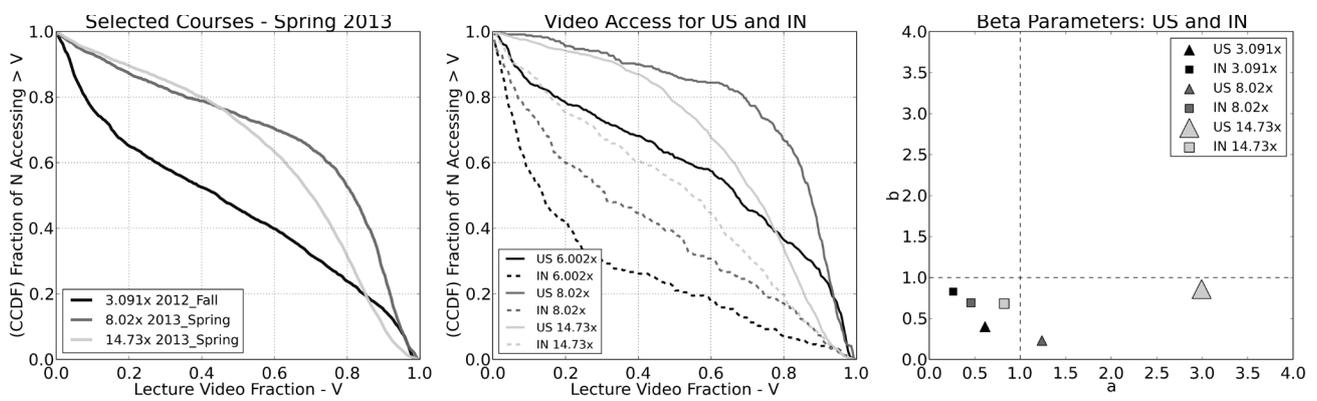


Figure 5. Fraction of videos accessed by certificate earners in 3.091x Fall 2012 and 8.02x Spring 2013. CCDFs (Left) are presented as a reference for comparing the separation of access distributions by the two largest enrolling countries (Middle): United States (Solid) and India (Dashed). Beta Parameters are plotted for each CCDF.

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Course Structure Considerations (considering removal)

Course structure refers to the type, order, and weight of various resources within a course. As a preliminary step toward understanding how course structure impacts video use, the following metrics are analyzed for all previously discussed MITx courses: the ratio of total lecture videos to lecture questions (frequency of occurrence), total hours of duration, and mean length of each video.

Figure 6 highlights these lecture video metrics. The video-question ratio (Left) gives perhaps the most compelling connection between bimodal video use and course structure. 6.002x has a tremendous number of lecture videos (see Table 1), leading to an inflated ratio, while 3.091x (the other bimodal course) has the next highest ratio of approximately 1.5. All other courses have video-question ratios near 1.0. Total time required to watch all videos (Middle) could potentially provide context into fatigue and time constraints, however, the connection between this metric is not as clear as that found in the video-question ratio (however, this metric will likely be more important in understanding temporal habits in future work). The mean video length (Right) as described here also lacks any strong connection between overall video accesses and course structure.

Discussion and Conclusions

Through the lens of unique lecture-video accesses, this study has provided a general overview of video use by certificate earners in MITx MOOCs. Bimodal video use measured from the inaugural 6.002x course has been confirmed to persist in repeated offerings utilizing the same content. In exploring this bimodality, country-of-origin was found to be an important factor influencing video use. However, country-of-origin did not account for the overall bimodal shape of distributions for all 6.002x offerings. For all MITx courses, two modes of video use have been observed: bimodal and high use. Country-of-origin was again shown to have significant influence on video use across courses, particularly for those courses with associated beta parameters existing near the boundaries of bimodal, high, and low video use.

Participants from India accounted for a large portion of certificate earners within MITx courses. Lecture-video use by participants from India was quite low relative to other countries in nearly all MITx courses. One aspect explored the simple idea that downloading videos due to poor Internet access may play a role in these observations; the reader is reminded click-stream data currently provide no information on participants that download lecture videos, instead, only indicating those participants streaming videos through their respective courseware. Downloading videos likely has some effect on low-video use in India, but other possibilities dealing with culture and learner preferences are not ruled out as contributing factors. Future efforts will be aimed at such effects.

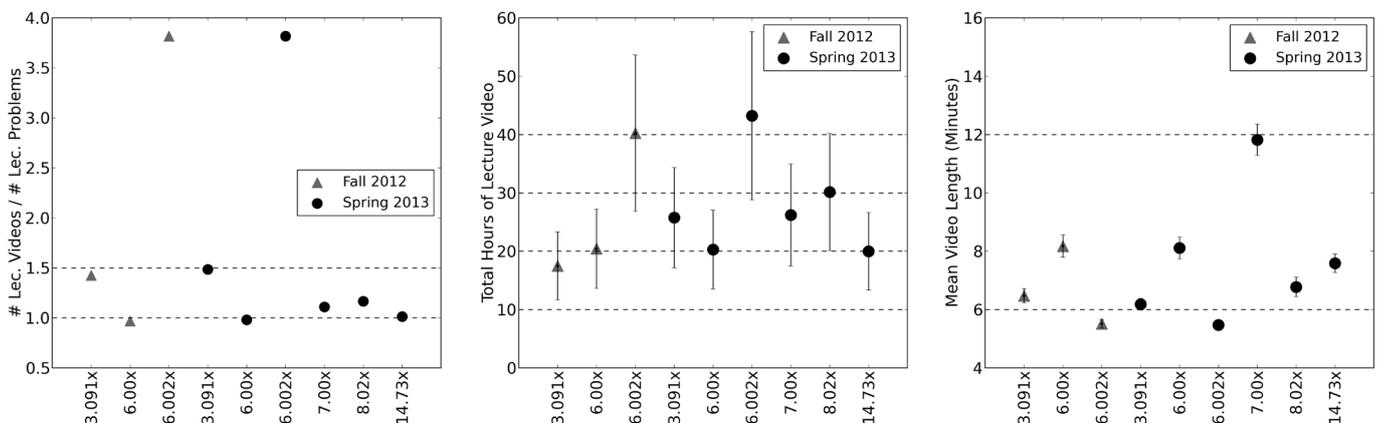


Figure 6. Visualization of Lecture Video features in all MITx courses: the ratio of Lecture Videos to Lecture Questions (Left) and the Total Duration in hours of all Lecture Videos watched in real time (Right). Error bars on total hours of lecture video denote the time difference in watching all videos at 0.75 or 1.5 times the normal speed. Error bars on Mean Video Length represent standard error of the mean. Dashed lines in both plots serve only as visual references.

Another important feature of this work involves the striking similarities in video use between repeated offerings of the same course. Minimal content changes were implemented in each course cycle for repeated course offerings, and behavior (interactions with videos) followed the same trend. Considering the certificate earning populations were still in the thousands of participants (barring 3.091 Spring 2013), this similarity makes a strong case that course structure impacts much of the student behavior. Courses with bimodal video use present an ideal setting in which to implement an experiment aimed at increasing video use through changes to course structure, i.e., the type, order, and weight of various resources within a course. Analysis of such experiments for on-campus physics courses using eTexts has begun (Seaton, Bergner, & Pritchard, 2013).

One promising result not directly addressed in this study involves the evolution of MITx courses. As new courses are introduced within each cycle, the overall number of videos being consumed is increasing. One might speculate that such an improvement is meaningful, but the value, whether toward learning or content delivery, must be better defined. Such metrics as those presented in Figure 6 are a first step in exploring how course evolution impacts video accesses. The relationship between the video-question ratio and bimodality presents a number of intriguing hypotheses for understanding video engagement. However, this work needs to be extended in order to account for the many types of possible engagement throughout a given course. Other important features not discussed here relate to content within each video, presentation style, and instructor effects, all of which could play an equally important role in overall video use. Recent work has implemented a deeper analysis involving the “in-video” interactions of MOOC participants, focusing on in-video dropouts and click activity (Kim, et al., 2014).

Much work remains in terms of identifying video access patterns in MOOCs. This work has taken a baseline approach that involves using participant-video interactions to count the number of unique videos accessed. Future work will likely incorporate improved metrics for analyzing video interactions, such as time-spent measures that monitor whether an interaction was meaningful (not simply clicking through to lecture questions), or measures of weekly video accesses that provide insight into changing habits over the roughly 16 weeks of an MITx course.

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