“A first course on mathematical modeling of structures and the mechanical behavior of deformable structural elements.” – edx.org

**Introduction.** 2.01x is a first course on the mechanical behavior of deformable structural elements. It introduces principles of structural analysis in applications to essential load-bearing elements, such as bars in axial loading, axisymmetric shafts in torsion, and symmetric beams in bending. The course covers fundamental concepts of continuum mechanics, including internal forces, displacement fields, stresses, and strains. The students learn to predict linear elastic structural behavior, and prevent failure, by relying on the notions of equilibrium, geometric compatibility, and constitutive material response.

2.01x was offered as an MITx on edX course in the Spring of 2013. It was taught by Dr. Simona Socrate, Professor Alexie M. Kolpak, and Kun Qian.

Many participants in MITx on edX courses come with different intentions and levels of interest and many resemble shoppers and auditors in their course activity. This report identifies four subpopulations of participants (numbers below): those who registered, viewed some course content, explored the course, and were certified.

<table>
<thead>
<tr>
<th>Important Dates</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 24, 2013</td>
<td>Registered 12,243</td>
</tr>
<tr>
<td>April 15, 2013</td>
<td>Viewed 8,283</td>
</tr>
<tr>
<td>July 30, 2013</td>
<td>Explored 1,563</td>
</tr>
<tr>
<td>September 8, 2013</td>
<td>Certified 814</td>
</tr>
</tbody>
</table>

1 See page 4 for definitions

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2.01x Course Report

January 21, 2014

Course structure refers to the type, frequency, and order of resources in a given course. Within an MITx course on edX\(^2\), course structure is composed of a few base resource types (problems, videos, html pages), each categorized under a specific course component. Figure 1 visualizes the 527 resources of 2.01x in terms of their course component categories, where each line indicates a separate resource, and the length approximates the weight of the component toward final course grade (lecture sequences do not count). Text labels indicate selected chapters, which are the highest level on the “courseware” menu that houses the course content.

For 2.01x, Lecture Sequences formed the base learning material released in each chapter. Each sequence consisted of videos (orange) taken from Dr. Socrate’s on-campus lectures and recitations by Professor Kolpak at MIT in 2013, with checkpoint questions (black) interspersed between nearly all videos. Graded assessment was administered through a combination of Homework (Silver) and Quizzes (Red). Homework included numerical and formula response, along with unique MATLAB-based code response questions (see page 7). Supplemental learning components (not pictured in Figure 1) included a threaded discussion forum for students and staff, and some highly produced picture and text animation screencasts by Dr. Socrate. No eText was required or used.

The release of chapters in 2.01x occurred over 15 calendar weeks. Final course grades were determined by nine homework sets (36%) and two quizzes (64%). Certification was granted to students whose final grades were 60% or greater.

\(^2\) Often colloquially referred to as a Massive Open Online Course (MOOC).

Figure 1: (Left) Course structure visualization highlighting course resource density, where the y-axis represents the temporal order of resources in the course. (Top) A legend providing context for each course component.
To date, MITx courses on edX have had similar schedules of regularly released resources and periodic due dates. Like 2.01x, courses have used quantitative assessment supported by lecture sequences and textual material, as well as a few special learning components (see end of this report). In the figures that follow, we compare 2.01x data with those from other MITx courses on edX, from the Fall of 2012 to the Summer of 2013.

**Demographics.** For 2.01x, we have records of 12,243 students who registered for the course by the cutoff date of this report, September 8, 2013. According to self-reported demographics, registrants were 84.1% men, and as a group, highly educated: 37.3% have earned bachelor’s degrees, 22.6% have masters or professional degrees, and 3.8% of registrants had earned a doctorate (for certified students, percentages are 32.1%, 31.6%, and 6.3%, respectively). Distributions of level of education and gender are plotted below in the top half of Figure 2, along with the average distributions for all MITx courses\(^3\). Note, roughly 6.5% of 2.01x registrants did not self-report one or more of the demographic categories.

\[\text{Figure 2: Distributions of demographic variables collected at registration: (top left) education attainment, (top-right) gender, (bottom left) age, and (bottom right) geolocation via IP look-up.}\]

As with other MITx courses on edX, 2.01x students came from all over the world. Based on geolocation of student IP addresses, 18.8% of registrants came from the United States, but many students also came from over 150 other countries around the world. Consistent with other MITx courses on edX, the median age of registrants and certified students was higher than those of typical MIT undergraduates; namely, 26 and 27 years, respectively. Distributions of geolocated country and age are plotted in Figure 2 for 2.01x, alongside the average distributions for all MITx courses.

**Participants in 2.01x.** Who are the students taking this course, and how much did they participate? The degree and kind of participation in the course varied considerably among those who signed up for 2.01x. Furthermore, like many MOOCs, this course remained open to new registrants, so that enrollment continued to rise through the semester. This asynchronicity is a key feature of open online courses. One feature of low barriers to registration, for example, is a large number of students who registered but never actually viewed any course material.

To illustrate the considerable variability in participants by their actions, we identify four subpopulations of interest within this course: those who (1) only registered, and never accessed the courseware, (2) only viewed, i.e. non-certified registrants who accessed at least one chapter but less than half of chapters, (3) only explored, i.e. non-certified registrants who accessed half or more of the chapters, and those who were (4) certified, by earning a final grade at or higher than the cutoff.

Certificate earners are the most conventional subpopulation, defined by crossing a certain threshold of achievement on quantitative assessments (well defined for 2.01x). The “only explored” subpopulation seeks to represent students having interacted with a considerable amount of course material, while the “only viewed” subpopulation highlights participants having only sampled the course. Both the “only explored” and “only viewed” subpopulations contain participants with highly varying levels of activity (as highlighted in the following two sections on persistence and activity). The fourth sub-population of "only registered" contains users that registered, but never accessed the courseware. This is a substantial number in 2.01x and many of the MITx courses on edX.
For 2.01x, the numbers of students who only registered, only viewed, only explored, or were certified, are shown in Fig. 3. The categories are defined as disjoint sets by using the “only” terminology, but the figure highlights the nested nature of registration, viewing, exploring, and certification. Students who were certified certainly viewed the course, but not all viewers were certified. Similarly, “explored” and “certified” are both subsets of viewed.

**Activity in 2.01x.** The activity of students in MITx courses on edX is logged; activity level can provide perspective into which courseware components are of interest to students, and which specific activities students are undertaking in a course, e.g. to earn certification.

How diverse is the activity of students in 2.01x? Consider the grade earned by students, which is determined in 2.01x by quantitative assessment with regular due dates and periodic exams. A scatter plot (Fig. 4) depicting earned grade versus the number of chapters visited, for each registered student, illustrates

**Figure 4:** Scatter plot of grade versus chapters viewed (left), highlighting student sub-populations; certified students are red points and all points are jittered. Histograms of grades and number of chapters viewed (right) distinguished by student certification status.

**Figure 5:** Distribution of clicks (total course interactions) and active days, distinguished by certificate status.
the distinctions between the sub-populations of students who only viewed, only explored, or became certified in the course. This plot also illuminates some possible registrant types: “completionists” (perfect grade, viewed all chapters), “optimizers” (occasional registrants that view minimal chapters but earn a certificate), and “listeners” (viewed all chapters, zero grade – submitted no work for credit).

For 2.01x, edX recorded 9,294,044 events in its tracking logs, relating to students interacting with the course contents, through the cutoff date of this report. These events included interactions indicating when students played videos, attempted problems, browsed through text pages, read or posted entries in the forum, and other activities. Fig. 5 gives a glimpse into these data, presenting a histogram of the total number of events (“clicks”) recorded for all registrants with at least one event, and highlighting the population of students who earned a certificate in comparison with all other students. The figure also presents a histogram of the number of active days, where “active days” represents any day where a course interaction was logged. The distribution of active days for certificate earners is broad, further reflecting the variety of approaches by which a participant can earn a certificate.

**Persistence in 2.01x.** How does the activity of students change as the course progresses, particularly with students who persist to earn certification? Figure 6 highlights courseware and course-site (pre-launch) interactions for three of the four disjoint subpopulations: only viewed, only explored, and certified. In 2.01x, there is a noticeable periodicity in each curve that is highly correlated with content release and due dates. Certified students show a relatively stable weekly periodicity, while the periodicity of the viewed and explored curves disappears after about one-third and two-thirds of the course, respectively. It is important to note that these curves do not account for registration

![Figure 6](image1.png)

**Figure 6:** Daily number of unique participants accessing courseware or course-site (pre-launch) via our described participant categories. Vertical dashed lines indicate the start and end of the course.

![Figure 7](image2.png)

**Figure 7:** Certification fraction versus registration week relative to course launch. Bubble size represents the number of unique users registering each week.
date or for large times between user interactions. However, they do provide insight into the collective behavior of our defined populations. It is particularly interesting to formulate hypotheses about behavior early in the course, e.g., attempting to target struggling students that may benefit from intervention.

Do students who register early have a higher likelihood of earning a certificate than students who register late? Figure 7 depicts the certification fraction versus registration week relative to course launch (bubbles indicate total enrollment each week). Across MITx courses, certification rates do not depend greatly on registration dates prior to launch, although some courses have higher registration rates very early as well as just prior to launch. For 2.01x, about 8% of users registering prior to launch earn a certificate regardless of enrollment week. After launch, the rate drops dramatically. Because of the highly structured due dates in 2.01x, it is reasonable to attribute most of the post-launch drop in certification rates to registrants who have missed due dates and find it difficult or impossible to catch up.

Special Features

Each MITx on edX course includes atypical features unique to the course. 2.01x had several features:

- **Matlab Problems.** 2.01x offered a unique problem type that allowed student submission and automated grading of Matlab code. This capability was unique among all the first year of MITx courses on edX. Matlab is a commercial numerical computing environment and programming language that is adept at matrix manipulations and especially effective for solving systems of differential equations of the kind often used in the 2.01x course. Students were asked to write Matlab code to solve problems, e.g. about structural forces and moments. The code was automatically graded in near real-time, using instructor-authored grading code (also written in Matlab). Plots produced by the code were also assessed, and displayed to students. This feature was made possible through collaboration with MathWorks.

- **Board Notes.** The 2.01x instructors provide extra notes for each lecture video, following, board by board, the material presented. The Board Notes were positioned as a helpful resource to review material in a time-efficient manner for students working on problem sets or preparing for the quizzes.

- **MATLAB “Hall of Fame” & Challenge Questions.** Students were occasionally given “challenge questions,” which went beyond the nominal course material, providing students an opportunity to go deeper into one aspect of a topic (e.g. shear stress and shear strain in torsion), as well as a chance to show off. The edX discussion forums were used as a venue for these questions, and student postings of answers. Included were Matlab code snippets for answering the problem, with plots showing student solutions. These resulted in ~100 forum posts, and inspired the instructors to select some of the best responses for a “Hall of Fame”.