“6.002x teaches the fundamentals of circuit and electronic analysis.”
– edx.org

**Introduction.** 6.002x introduces engineering in the context of the lumped circuit abstraction. Topics covered include: resistive elements and networks; independent and dependent sources; switches and MOS transistors; digital abstraction; amplifiers; energy storage elements; dynamics of first- and second-order networks; design in the time and frequency domains; and analog and digital circuits and applications. Design and lab exercises are also significant components of the course.

6.002x was offered as a MITx on edX course in the Fall of 2012, by Professor Khurram Afridi (visiting MIT); the course had previously been developed by Professors Anant Agarwal and Gerald Sussman, Dr. Chris Terman, and Dr. Piotr Mitros.

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.

### Important Dates

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 24, 2012</td>
<td>Registration Open</td>
</tr>
<tr>
<td>September 5, 2012</td>
<td>Course Launch</td>
</tr>
<tr>
<td>December 25, 2012</td>
<td>Course Close</td>
</tr>
<tr>
<td>September 8, 2013</td>
<td>Date of Report Data Collection</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Participants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered</td>
<td>51,394</td>
</tr>
<tr>
<td>Viewed</td>
<td>33,349</td>
</tr>
<tr>
<td>Explored</td>
<td>4,880</td>
</tr>
<tr>
<td>Certified</td>
<td>2,987</td>
</tr>
</tbody>
</table>

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1 See page 4 for definitions

This report was produced jointly by the MIT Office of Digital Learning, and the HarvardX Research Committee.

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 658 base resources of 6.002x 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 6.002x, Lecture Sequences formed the base learning material released in each chapter. Each sequence contained videos (orange) consisting of a combination of recorded on-campus lectures at MIT and tablet annotations by Professor Agarwal. Finger exercises (black) were interspersed within each sequence at a rate of roughly one to every four videos. Graded assessment was administered through a combination of Homework (silver), Online Laboratories (green), and Examinations (red). Homework included numerical and formula response, while the Online Laboratory contained an interactive circuit simulator. Supplemental learning components not pictured in Fig. 1 included a threaded discussion forum for students and staff, an eText, a staff-student editable wiki, and ungraded access to the interactive circuit simulator.

The release of chapters in 6.002x occurred over 15 calendar weeks. Final course grades were determined by twelve homework sets (15%), twelve online laboratories (15%), a midterm (30%), and a final exam (40%). Certification was granted to students with final grades of 60% or greater.

\(^2\) Often colloquially referred to as a Massive Open Online Course (MOOC)
To date, MITx courses on edX have had similar schedules of regularly released resources and periodic due dates. Like 6.002x, 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 7.00x data with those from other MITx courses on edX, from the Fall of 2012 to the Summer of 2013.

**Demographics.** For 6.002x, we have records of 51,394 students who registered for the course by the cutoff date of this report, September 8, 2013. According to self-reported demographics, registrants were 87.0% men, and as a group, highly educated: 41.9% have earned bachelor’s degrees, 15.9% have masters or professional degrees, and 3.4% of registrants had earned a doctorate (for certified students, percentages are 34.0%, 21.6%, and 3.4%, 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. Note, roughly 5% of 6.002x registrants did not self-report one or more of the demographic categories.

**Figure 2:** Distributions of demographic variables collected at registration for all registrants reporting data, with MITx-wide comparisons for reference: (top left) education attainment, (top-right) gender, (bottom left) age, and (bottom right) geolocation via IP look-up.

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As with other MITx courses on edX, 6.002x students came from all over the world. Based on geolocation of student IP addresses, 26.4% of registrants came from India (15.7% 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 were higher than those of typical MIT undergraduates; namely 25 and 25 years, respectively. Distributions of geolocated country and age are plotted in Fig. 2 for 6.002x, alongside the average distributions for and all MITx courses.

Participants in 6.002x. 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 6.002x. 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 6.002x). The "only explored" subpopulation seeks to represent students having interacted with a considerable amount of course material, while the "only viewed" subpopulation seeks to highlight 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 6.002x and many of the MITx courses on edX.

For 6.002x, 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 6.002x. 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 the course? Consider the grade earned by students, which is determined in 6.002x by quantitative assessment with regular due dates and periodic exams. A scatter plot (Figure 4) depicting earned grade versus the number of chapters visited, for each registered student, illustrates 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 6.002x, edX recorded 35,313,162 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. Figure 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.

![Figure 5: Histogram of 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.](image)

**Persistence in 6.002x.** 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 disjoint participant types: only viewed, only explored, and certified. In 6.002x, 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 date or for large times between user interactions. However, they do provide insight into the collective

![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.](image)

**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: Certification fraction versus Certification fraction versus registration week relative to course launch. Bubble size represents the number of unique users registering each week.](image)

**Figure 7:** Certification fraction versus Certification fraction versus registration week relative to course launch. Bubble size represents the number of unique users registering each week.
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
registration dates prior to launch, although some courses have higher registration rates very early as well as just prior to
launch. For 6.002x, a relatively flat (possibly increasing) pre-launch plateau is seen, where roughly 10% 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 6.002x, 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 special features unique to that course. 6.002x had the following features:

- **Circuit Simulator**: As a proxy to physical laboratories, 6.002x provided students an opportunity
to experiment with circuit design in a web-based schematic capture and simulation tool. Students
could place and wire up voltage sources, resistors, MOSFETs, and
voltage probes. The diagrammed circuit could then be electrically simulated, generating time-domain
and frequency-domain plots. This simulation tool was also used as an assessment tool; for example,
students were asked to design a gate using only three MOSFET switches; the diagram constituted
the student’s submission, which was automatically graded by the edX platform. Professor Jacob
White and Dr. Chris Terman developed the simulation engine.

- **Video competition**: Students in the course self-organized a “Circuits and Electronics Classmates
  Contest,” in which course participants were invited to submit videos describing 6.002x course content
  theory put into practice. A panel of students judged entries, with the winner being a student
demonstrating digital control of a DC motor with pulse-width modulation.

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6 Mitros, Afridi, Sussman, Terman, White, Fisher, and Agarwal, Proceedings of the IEEE International Symposium on Circuits and
Systems, Beijing, China, May 2013