“8.02x presents the basic concepts of Electromagnetism, and how this touches upon a vast variety of interesting real-world physics.” – edx.org

Introduction. 8.02x is the second course in the MIT introductory physics sequence on electricity and magnetism. The course covers electric fields, magnetic fields, electromagnetic forces, conductors and dielectrics, electromagnetic waves, and the nature of light. The 8.02x online version follows the MIT on-campus class as it was given by Professor Walter Lewin in the spring of 2002, and includes his video lectures and problem solving sessions. The course also contains animations and interactive simulations developed under Professor John Belcher for MIT’s Technology Enabled Active Learning (TEAL) classroom.

8.02x was offered as a MITx on edX course in the Spring of 2013. In addition to Professors Lewin and Belcher, course staff included Dr. Ricardo Abbate, Dr. Peter Dourmashkin, Dr. Saif Rayyan, Dr. George Stephans, and Professor Isaac Chuang.

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 defines four overlapping subpopulations of participants (numbers below): those who registered, viewed some course content, explored the course, and were certified¹.

<table>
<thead>
<tr>
<th>Important Dates</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 17, 2013 Registration Open</td>
<td>Registered: 41,307</td>
</tr>
<tr>
<td>February 18, 2013 Course Launch</td>
<td>Viewed: 27,912</td>
</tr>
<tr>
<td>June 18, 2013 Course Close</td>
<td>Explored: 3,242</td>
</tr>
<tr>
<td>September 8, 2013 Date of Report Data Collection</td>
<td>Certified: 1,716</td>
</tr>
</tbody>
</table>
Course structure refers to the type, frequency, and order of resources in a given course. Within an MITx course on edX\textsuperscript{2}, course structure is made up of a few base resource types (problems, videos, html pages), each categorized under a specific course component. Figure 1 visualizes the 1158 resources of 8.02x ordered according to their appearance in the course, 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 8.02x, Lecture Sequences formed the base learning material released in each chapter. Each sequence consisted of videos (orange) taken from Professor Lewin’s on-campus lectures at MIT in 2002, with every video followed by a checkpoint question (black). Homework (silver) and examinations (red) made up of numerical and formula response questions provided high-level assessments similar to those in the residential version of the course, 8.02. Supplemental learning components included interactive simulations (green) designed by Professor Belcher for TEAL at MIT, and problem solving tutorial videos (blue) from Professor Lewin. Supplemental learning components not pictured in Figure 1 included a threaded discussion forum for students and staff, a student- and staff- edited wiki, and eText based on notes from the residential course, 8.02 (Liao, Dourmashkin, and Belcher [2013]).

The weekly release of chapters in 8.02x occurred over 17 calendar weeks, about the same length as the MIT residential version. Grades in 8.02x were determined by nine homework sets (18%),

\textsuperscript{2} Often colloquially referred to as a Massive Open Online Course (MOOC)
three midterms (15% each), and a final exam (30%). The lecture sequences (5%) and TEAL simulations (2%) had smaller weights but were graded to encourage participation. Certificates were granted to students whose final grades were 60% or greater.

To date, MITx courses on edX have had similar schedules of regularly released resources and periodic due dates. Like 8.02x, other courses have used quantitative assessments, lecture sequences, and textual material, as well as a few learning components unique to particular courses (see end of this report). In the figures that follow, we compare 8.02x data with those from other MITx courses on edX, from the Fall of 2012 to the Summer of 2013.

**Demographics.** For 8.02x, we have records of 41,037 students who registered for the course by the cutoff date of this report, September 8, 2013. According to self-reported demographics, registrants were 83.8% men, and as a group, highly educated: 34.6% have earned bachelor’s degrees, 19.5% have masters or professional degrees, and 4.9% of registrants had earned a doctorate (for certified students, percentages are 26.9%, 30.1%, and 8.5%, respectively). Distributions of level of education and gender are plotted in the top half of Figure 2 below, along with the weighted average for all MITx courses\(^3\). Note, roughly 7.7% of 8.02x registrants did not self-report demographics.

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As with other MITx courses on edX, 8.02x students came from all over the world. Based on geolocation of student IP addresses, 34.2% 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 were higher than those of typical MIT undergraduates; namely, 25 or 28 years respectively. Distributions of geolocated country and age are plotted in Fig. 2 for 8.02x, alongside the unweighted average for all MITx courses.

**Participants in 8.02x.** 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 8.02x. 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 8.02x). 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 8.02x and many of the MITx courses on edX.

For 8.02x, 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 8.02x.** 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 8.02x 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 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).

**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, above) and active days, (below) distinguished by certificate status.
For 8.02x, edX recorded 37,394,406 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 8.02x.** Figure 6 highlights courseware and course-site (pre-launch) interactions for three of our disjoint participant types: only viewed, only explored, and certified. In 8.02x, 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 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.

**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. Due to data loss, some information about user activity between January 21 and Feb 13 is missing and not included in the plot.

**Figure 7:** Certification fraction versus absolute course week. Bubble size represents the number of unique users registering each week (count plotted for max fraction certified).
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 8.02x, roughly 6% of users registering prior to launch earn a certificate regardless of enrollment week, excepting a spike five weeks before launch. Because of the highly structured due dates in 8.02x, 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. 8.02x had several such features:

- Sophisticated and physically accurate interactive technology enabled active learning ("TEAL") simulations of electromagnetic phenomena (all simulations were embedded within the course and useable with native, un-enhanced web browsers). TEAL simulations bring forth technology developed over a decade of work at MIT in Physics, by Professor John Belcher and team. Simulations include depictions Gauss’ and Faraday’s laws, showing the fundamental behavior of point charges and current loops in static and dynamic electric and magnetic fields. Students interact with the fields, move particles, rings, and other simulation elements, just as they would in a real physical experiment. Three-dimensional visualizations of fields are rendered in real time within the browser. In the course-exit survey, a majority of students identified the TEAL simulations as the course component that most improved their understanding of the course material.

- Lectures in 8.02x were provided by Professor Walter Lewin, whose lectures have been viewed millions of times on YouTube and covered extensively in the press. These lectures were originally recorded for MIT OpenCourseWare, and were reformatted in higher resolution for 8.02x. Professor Lewin participated actively in the discussion forum, regularly answering student questions.

- Assessments featured randomized problems, where each student received different numerical parameters, and correct answers differed across students. Problem set and exam questions were designed to match the difficulty of the on-campus course, although students on edX were given more time for the exams than campus students typically are.