In the summer of 2013, faculty members at the University of Minnesota collaborated with staff from the university’s Office of Information Technology and provost’s office to deliver five massive open online courses (MOOCs) using the Coursera platform. The courses were chemistry/thermodynamics, social epidemiology, health informatics, global food systems/sustainability, and canine theriogenology. The five courses enrolled as many as 71,029 students, although an enrollee’s commitment to a course could be as nominal as clicking a button on Coursera’s website. We also offered one MOOC in computer science in fall 2013 parallel with a face-to-face section of that course.

As part of these relatively early forays into MOOCs, we wanted to better understand their pedagogical impact. Conducting systematic, reliable research in a MOOC environment is challenging, however, for several reasons:

- **Lack of student commitment/effort.** Many MOOC enrollees are just testing the MOOC environment, and it is challenging to get them to take tests, write assignments, or fill out surveys.

- **Different student populations.** While we have a certain amount of confidence regarding factors that promote or hinder learning among traditional-age college students on our physical campuses, we do not know what variables affect student experience or performance in MOOCs, particularly because MOOCs reach a population very different from the one usually studied by educational researchers.

- **Elusive baseline measures.** Because we have no data on MOOC students—such as what classes they have taken and what their majors and GPAs are—we do not know where they are starting in terms of content knowledge or their general aptitude for the courses they are taking.

- **Student attrition.** Because students enter and leave MOOCs at will, data about MOOC users varies considerably depending on measures used and when samples are taken, making it challenging to draw conclusions.

Our project sought to use appropriate evaluation methods to address each of these challenges.
1. Project Overview

1.1. Project Goals, Context, and Design

Overall, we had several broad objectives. We sought to better understand the faculty experience in creating and delivering MOOCs. We wanted a deeper understanding of the student experience in MOOCs and how students were affected by that experience. We sought to clarify determinants and different measures of student progress and completion in MOOCs. We also wanted to identify factors that might predict student performance in MOOCs, at least for students who completed all or most of the coursework. Specifically, we sought to answer several related research questions:

- How much time and effort does it take to produce and deliver a MOOC, both for instructors and teaching assistants and for IT staff involved in project management and production?
- Do factors traditionally associated with successful course completion and learning also predict success and learning in MOOCs?
- How does one define and measure successful completion in a MOOC? How does one measure learning in MOOCs, especially without traditional predictors or controls?
- Do students learn in a MOOC? If so, how does learning in a MOOC compare to learning in a face-to-face course?

1.2. Data-Collection Methods

Our data-collection methodology encompassed several measures:

- **Time and effort diaries.** We developed time and effort reporting forms to measure the expenditure of individual effort in course planning (including learning about MOOCs, course and instructional design, creating written content, creating media content, creating assignments and assessments, and outreach via media and advertising) and course execution (including course monitoring, planning, participating, and grading). These time diaries were sent weekly to instructors and teaching assistants (see appendixes A and B). In addition, IT staff logged hours dedicated to MOOC projects.

- **Pre- and postcourse surveys.** We incorporated relevant demographic and theoretical variables into pre- and postcourse surveys (see appendixes C and D). The surveys asked about students’ motivations for enrolling in the MOOC and requested background information, such as age, sex, ethnicity, education level, English proficiency, and country of origin. The surveys included factors related to student completion of the MOOC, such as intent to complete, self-reported completion, and obstacles to completion. The surveys also included course evaluation measures for the instructor.

- **Measures of learning.** One course instructor developed a knowledge test to assess pre- and postcourse knowledge. The knowledge test contained items with varying levels of difficulty to appropriately discriminate levels of expertise and prior knowledge.

- **Faculty interviews.** We conducted semi-structured (conversational) interviews with the six instructors who volunteered for this project and received no incentive to teach the MOOCs. Given the variation in their levels of experience teaching online, we focused on issues related to their experiences planning, creating, and teaching MOOCs.

- **Vendor data.** Coursera provided analytics of student behavior in the MOOCs drawn from learning management systems and relevant gradebook data.
1.3. Data-Analysis Methods

Quantitative data analysis was performed using SPSS and STATA software. Within groups, we analyzed descriptive statistics to examine central tendencies and variability of student population variables. Using cross-sectional analyses, we investigated potential differences between subgroups (e.g., men versus women; U.S. residents versus non-U.S. residents; older versus younger students) in their experience in the MOOCs. We used exploratory factor analysis to identify underlying structures in students’ responses to pre- and post-survey questions.

We also conducted analyses between groups, including difference-of-means tests to locate variables on which MOOC and face-to-face student responses diverged significantly. We also used multivariate modeling to understand the influence of different sets of predictor variables on student completion and success in the MOOCs.

1.4. Findings

We identified findings in several broad areas, including time and effort, motivations and reasons, and learning in a MOOC versus learning face-to-face.

Time and effort. As shown in table 1, self-reported instructor and TA time for planning MOOCs averaged 222.47 hours per course. There was considerable variation among the courses, however. The high was 272.50 hours; the low was 19.92 hours. The lower end of that scale can be attributed to mitigating factors: The course on canine theriogenology had existed previously as a regular for-credit online course, and development involved migrating existing materials to the MOOC platform. Self-reported instructor and TA time for executing MOOCs averaged 157.57 hours per course. Again, there was considerable variation, ranging from a high of 205.50 hours to a low of 52.35.

Table 1. Instructor and TA self-reported effort in hours

<table>
<thead>
<tr>
<th>Course</th>
<th>Planning</th>
<th>Executing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Molecular Thermodynamics</td>
<td>207.50</td>
<td>205.50</td>
<td>413.00</td>
</tr>
<tr>
<td>Sustainability and Food Systems</td>
<td>272.50</td>
<td>157.50</td>
<td>430.00</td>
</tr>
<tr>
<td>Interprofessional Health Care Informatics</td>
<td>263.00</td>
<td>56.00</td>
<td>319.00</td>
</tr>
<tr>
<td>Social Epidemiology</td>
<td>114.50</td>
<td>74.50</td>
<td>189.00</td>
</tr>
<tr>
<td>Canine Theriogenology for Dog Enthusiasts</td>
<td>19.92</td>
<td>52.35</td>
<td>72.27</td>
</tr>
<tr>
<td>Unidentified and TAs</td>
<td>234.95</td>
<td>242.00</td>
<td>476.95</td>
</tr>
<tr>
<td>Total</td>
<td>1,112.37</td>
<td>787.85</td>
<td>1,900.22</td>
</tr>
<tr>
<td>Average</td>
<td>222.47</td>
<td>157.57</td>
<td>380.04</td>
</tr>
</tbody>
</table>

Time spent by IT staff developing MOOCs averaged 340.9 hours per course. When those hours were added to time spent by instructors and TAs, the total average time spent for developing a MOOC was 720.9 hours per course.

Motivations and reasons. To better understand the students who had signed up for the MOOCs, we administered precourse surveys to gather demographic and other background information. We achieved a response rate of 29.82%, a rate that exceeds typical levels achieved by surveys of students in face-to-face circumstances. However, as with most survey research, we lacked an independent source of data about survey respondents and therefore cannot determine how representative our sample is.
Among other important dimensions, we sought insight into why students take a MOOC. We asked a dozen individual questions about the strength of various reasons and conducted an exploratory principal components analysis on the data. That analysis identified four categories of student motivations:

- **Enjoyment related** (e.g., “I think taking this course will be fun and enjoyable”)
- **University related** (e.g., “This course is offered by a prestigious university”)
- **Access related** (e.g., “I am not geographically close to educational institutions”)
- **Professional related** (e.g., “This class teaches skills that will help my job/career”)

Applying these four aggregated theoretical dimensions in our analysis, we were able to then ask what predicts a student’s having certain sorts of reasons for taking a MOOC and whether having particular motivations correlated with other student factors.

One finding was that enjoyment-related reasons were dominant. We found this particularly interesting given that these MOOCs covered serious topics and were not what might be called “lifestyle MOOCs” focused on lighter subjects. Virtually all respondents indicated they were motivated by such factors as interest in the subject matter and pure enjoyment in learning. (In addition, of course, some students said they were also motivated by other factors.)

We found that the different sets of reasons for taking a MOOC divided the MOOC student population along demographic lines. Living outside the United States, being a nonnative English speaker, being a student or a professional in a related field, being a graduate student, and being male are all significantly and positively associated with stronger reasons for taking a MOOC in three categories: university related, access related, and professional related. But those characteristics are significantly and negatively associated with enjoyment-related reasons for taking a MOOC (see figure 1).

![Figure 1. Demographic characteristics and reasons for taking MOOCs](image-url)
In terms of motivations for taking a MOOC, we found that students could be divided generally into two broad populations, which we labeled “strivers” and “grazers.” Strivers tend to live outside the United States, are younger, and are mostly men who may well be graduate students with nonnative English skills. This population tends to emphasize all of the reasons for taking a MOOC except the enjoyment-related reasons, and they report completing a greater proportion of their MOOCs. Grazers, on the other hand, tend to live in the United States, are more likely to speak English natively, and are less likely to be graduate students or students who work and study in a field related to the MOOC in which they enrolled. This population emphasizes the enjoyment-related reasons for taking a MOOC and is less likely to complete more of the MOOC than they planned. In addition, the striver population appears to be eager to gain the skills and knowledge that MOOCs provide, and there is some indication that this population performs better in MOOCs than do grazers. It is important to note, however, that these are tendencies only; it is certainly not the case, for example, that all male students are strivers and all female students are grazers.

**Learning in a MOOC versus learning face-to-face.** Our study of a computer science course, Introduction to Recommender Systems, enabled us to compare a section of the course in MOOC format through Coursera with another section offered simultaneously on campus, for credit, using both the Coursera platform and a flipped classroom instructional model. We held constant as many variables as possible between the two sections, including the instructor and TAs, readings, assignments, quizzes, and tests, so that we could meaningfully compare the learning outcomes achieved by students in the two sections.

It is usually difficult to systematically study the differences in learning between face-to-face and MOOC students, due to the lack of a measure of baseline understanding or knowledge. In this study, however, a precourse knowledge test developed by the professor in the course provided that baseline measure (see appendix E). Comparing face-to-face students and online students who took both the pre- and postknowledge tests, we found that the two groups of students were statistically equivalent in terms of the knowledge they had about recommender systems when they began the course. We then calculated normalized learning gains for each student, defined as posttest score minus pretest score divided by the magnitude of possible knowledge gains. This measure takes a student’s starting point into consideration and tries to account for the fact that it is more difficult to make gains when one begins near the top of the testing scale.

As a final step, we compared the two groups in terms of the normalized gains in knowledge they achieved over the semester. We found that while both groups showed significant learning gains, there was a nominal difference of 8.4% favoring the face-to-face students. This difference was moderate in size (about one-third of a standard deviation), although the very small N in the face-to-face group prevented this effect from attaining statistical significance. Figure 2 summarizes our findings.
1.5. Communication of Results

The results of this study have been communicated to faculty and administrators on the University of Minnesota campus through presentations to a variety of governing committees. They have also been disseminated through scholarly channels, including the 2014 ELI Annual Meeting in New Orleans, the 2014 Learning at Scale conference in Atlanta, and the 2014 SLOAN-C conference in Orlando, as well as in the *Journal of Veterinary Medical Education*, the proceedings of the first ACM conference on Learning at Scale, and *ACM Transactions on Computer-Human Interaction*. Findings from this study informed the decision by the Office of Information Technology and the provost’s office at the University of Minnesota to offer a second round of MOOCs in spring/summer 2014.

1.6. Influence on Campus Practices

The broad reach of MOOCs has arguably increased faculty interest in teaching courses in this format. Teaching courses to students from a wide variety of cultural backgrounds has motivated faculty members to revise how they present course material. Feedback from students has refined and streamlined the production of video presentations for general online delivery. Many of the materials produced for the Minnesota MOOCs are being repurposed for use in conjunction with face-to-face classes on campus.

2. Reflection on Design, Methodology, and Effectiveness

2.1. Project Design, Data Collection, and Analysis

This project’s research design and data-collection methods explicitly sought to compensate for the difficulties normally associated with conducting research on MOOCs. Specifically, for example, we found that MOOC students did not complete surveys at rates any lower than those associated with surveys of on-campus students. Moreover, the large numbers of students who enroll in MOOCs enabled relatively easy analysis of student subpopulations. However, given the lack of information about survey nonrespondents, it was not possible to compensate or adjust for nonresponse bias as one can with a survey of face-to-face students.
Through our collection of precourse student data and our multivariate predictive modeling, we tried to determine whether the predictors of student success and completion in MOOCs are different from the predictors associated with on-campus students. Identifying and understanding these predictors warrants further investigation.

Our precourse surveys were crucial in understanding students in MOOCs and in creating variables that could be used, and controlled for, in predictive analyses. The precourse knowledge test in the course on recommender systems was particularly useful in establishing the comparability of the groups of students whose learning gains we wanted to compare.

It was necessary at several points to be mindful of both qualitative and quantitative differences in the sample of students who completed different surveys and tests. For example, in the recommender systems course, it was important to not simply compare students’ mean pretest scores with mean post-test scores in order to assess the overall magnitude of students’ learning gains. Some 4,844 students took the pre-class knowledge test, but just 304 took the post-test, suggesting that that a certain degree of selection took place with only strong students remaining in the class long enough to take the post-test. To ensure that the result is not spurious, a paired test is necessary.

2.2. Effectiveness and Influence on Campus Practices
Given that the MOOC initiative is an ongoing one at the University of Minnesota, final conclusions about the effectiveness and influence of this research on campus practices are tentative. Nonetheless, our study provided clear information to instructors of future MOOCs about the amount of time and effort required to produce and deliver a MOOC. The study helped inform IT managers about the allocation of IT resources (project management, production, research) required to deliver a MOOC. Finally, the study helped the university understand the efficacy of select new educational technology initiatives and underscored the critical importance of incorporating assessment and evaluation protocols at the very beginning of such initiatives to help ensure securing optimally meaningful and useful data.

3. Supporting Materials