Drivers of Quality in Online Learning

How to Increase Engagement, Satisfaction, Skill Development, and Career Impact Worldwide

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Executive Summary

ACTIONABLE TAKEAWAYS FOR INSTRUCTORS

Help learners apply their new skills

Hands-on projects and programming assignments can drive 30% higher rates of skill development, in addition to gains in satisfaction and career outcomes. Robust assignments are more difficult but well worth the effort.

Chunk video content appropriately

Shorter videos help learners benefit from the increased flexibility in online learning. Keep lectures under 10 minutes long to improve lecture completion rates by 16% and increase learner satisfaction.

Leverage in-browser experiences

Course completion rates in programming courses with in-browser experiences (like Coursera Labs) are 20% higher than in those with offline programming assignments.

Ensure proper course length

Courses that are roughly one month long have the highest completion rates, and ensuring each week covers concepts in sufficient depth is crucial for career outcomes. Guided Projects are great options for delivering efficient, hands-on learning for those seeking to demonstrate their skills.

Provide opportunities for practice

Practice assignments, activities, and in-video questions increase skill development and career outcomes.

ACTIONABLE TAKEAWAYS FOR LEARNERS

Start strong

Learners who stay up to date with their deadlines for the first two weeks are almost twice as more likely to remain engaged until course completion.

Return frequently

Learning multiple times a week increases retention relative to longer and less frequent learning sessions.

Don't rush

Learners who spend more time watching and reviewing videos complete courses at higher rates than learners who skim through them. Take advantage of the flexible pace and make sure you understand foundational concepts.

Find the right fit

Learners who choose courses that are at the appropriate difficulty level gain the highest levels of skill development.

Incorporate social learning

Learners who participate in discussion forums early on are 25% more likely to complete the course. Engaging with a community helps learners reach their goals.

PURPOSE OF THIS ANALYSIS

We have ample evidence that online learning can be highly effective across a variety of quality metrics. Although the goals and motivations of online learners vary widely, completion rates among most populations of learners are substantially higher than 50% and can be far higher in courses that adhere to Coursera pedagogy best practices.

Among the learners who do engage effectively, the satisfaction and outcomes are, on average, impressively high. The average star rating across courses on Coursera is 4.7 out of 5 stars, showing that learners do indeed enjoy their online learning experiences, even when they involve large investments of time and effort. More importantly, online courses are able to truly have a transformational impact on the lives of those who complete them. 73% of learners report positive, job-related outcomes from completing their courses, a great testament to how online courses can impart skills valuable to learners' daily lives.

Given all we have learned, we present here the most important takeaways for instructors and learners who are either new to online learning or want to continue to improve the quality of their experiences.

Introduction

Coursera was founded by Daphne Koller and Andrew Ng with a vision of providing life-transforming learning experiences to anyone, anywhere. It is the leading online learning platform for higher education, where 70 million learners from around the world come to learn skills of the future. By partnering with more than 200 of the world's top universities and industry leaders, Coursera offers over 4,000 courses, Guided Projects, Specializations, Professional Certificates, MasterTracks, and full degree programs.

WHY QUALITY ONLINE EDUCATION MATTERS MORE THAN EVER

As a result of COVID-19[1], which disrupted traditional learning for over one billion students, learners and instructors globally are turning to online education as a necessity. Many are new to the online setting and unsure of how to set up their learning and teaching for success. With years of data[2] across nearly 200 million online course enrollments, Coursera is uniquely positioned to share how online teaching can increase engagement, satisfaction, skill development, and career impact for learners around the world. Not all online learning is equal. Our analysis sheds light on what works best and why.

HOW WE MEASURE QUALITY

Defining "quality" in online learning is important as there is no singular metric that fully captures the diversity of experiences and outcomes. Learners and instructors come from a wide range of backgrounds and have a variety of goals. This paper evaluates quality with a nuanced set of measurements that together capture how well a course helps learners acquire knowledge and skills. Table 1 describes the four components of quality we analyze in this report.

The first, most fundamental measurement of quality in online learning is **engagement**. Engagement is the degree to which learners who enroll in a course make progress and complete learning activities. It is the minimum bar to ensure that learners actually derive value from a course — if learners aren't completing the assigned learning activities, we can safely assume the educational experience is not a productive one. Although course completionfor a massive open online course (MOOC) is a coarse measure of engagement, it offers a strong, relative signal of how well the course is set up for those learners who are trying to finish.

For the learners who engage with the material, **satisfaction** adds an additional layer of information for how they value the course experience. Coursera offers learners the ability to rate each course from 1 to 5 "stars." This direct feedback allows us to determine which courses are most valued by the learners who spend time engaging with them. This rating helps to paint a more complete picture of learning experiences than measures of engagement alone.

In addition to engagement and satisfaction, we also observe how valuable the learning experience is to each learner who enrolls in a course. Using Coursera's skill scoring algorithm[3], we quantitatively assess how much **skill development** happens for each learner over the course of the enrollment period. This measurement allows us to compare the educational output of each enrollment (a learner in a course), to determine when substantial knowledge gains have taken place.

The final consideration is **career impact**. The majority of learners on Coursera have career-oriented goals when they sign up for a course. Using a survey sent to course completers six months after completion, we track whether or not the course provided an impact on their career. If the ultimate goal of online education is to transform lives through learning, then this is a crucial piece in assessing the quality of each learning experience.

This report is intended as a guide for instructors and learners who are navigating the world of online learning. As we explore each component of quality, our goal is to highlight actionable insights that can be used to assist both instructors and learners as they seek to create successful online educational experiences.

TABLE 1. Components of quality metric definitions

Component of Quality	Metric	Definition
Engagement	Completion rate	The proportion of completion-eligible learners who complete courses and items.
Satisfaction	Rate of 5-star reviews	The proportion of star ratings — given by course completers — that are a perfect 5 stars. This metric captures more variability than average star ratings.
Skill Development	Average Score Delta	The average increase in skill scores, demonstrated in graded assignments, assessments, and projects in the course.
Career Outcomes	Rate of career benefit	The proportion of completers, responding to our survey, who report receiving career benefits from the course.

1 UNESCO https://en.unesco.org/covid19/educationresponse

2 For the purposes of this report we focus on enrollments since 2016, when Coursera shifted to an on demand platform for learning where course material is continuously available. Enrollments that are part of for-credit degree and certificate programs are also excluded.

3 Using a Glicko-based Algorithm to Measure In-Course Learning

Data and Methods

The subsequent four sections of this report each cover one of the four components of quality outlined in the introduction. To maintain consistency, we replicate a standardized analysis methodology for each section with the goals of describing the distribution of the metric and then identifying the most actionable ways for instructors and learners to influence it.

DEFINING KEY METRICS

The first step in our analysis is to provide an overview of the metric and how it is distributed across the course catalog. This provides intuition about the typical range of values we observe and illustrates some of the overarching course characteristics that correlate most strongly with each metric. We analyze each metric using an appropriate dataset, which is specified to ensure we are drawing conclusions from reliable and meaningful observations. The analysis for each metric of interest can happen at the course level (using aggregated numbers) or at the enrollment level (using measurements for each learner in each course). Details on the datasets are available in Appendix A.

RELATING METRICS TO ACTIONABLE DRIVERS

In addition to overviewing each metric, the core focus of this report is to identify actionable insights for how instructors and learners can make the most of an online learning experience. We construct statistical models for each of our quality metrics in order to assess the impact of potential drivers — variables that either instructors or learners typically have the ability to influence directly. Again using the datasets described in Appendix A, we calibrate statistical models for either courses or individual enrollments. The level of granularity and the specification of each model depend on which metric is being analyzed, and are described in more detail within the individual sections.

Table 2 displays the set of drivers we consider in this report for both instructors and learners. For instructors, we focus on drivers that represent course authoring decisions that are relevant for the majority of courses, although some are specific to technical subject areas. For learners, we select drivers that are the manifestations of real choices that learners make when attempting to complete (or select) a course. We avoid analyzing drivers that are mandatory based on what the instructor is attempting to teach, or based on what the learner is required to do to complete. More detailed definitions of these drivers can be found in Appendix A.

TABLE 2A. Drivers relevant to learners

Category	Drivers
Course Progress	• Graded item progress • Percent of videos completed • Percent of ungraded items completed
Learning Patterns	• Time spent learning • Learning sessions • Days active • Video watching pace
Social Learning	• Days accessing forum • Is Forum Participant
Course Choice	• Relative course difficulty

TABLE 2B. Drivers relevant to instructors

Category	Drivers
Course Length	• Number of weeks • Learning time per week • Learning time week 1 vs. avg week • Items per week
Course Composition	• Videos as percent of items • Videos as percent of learning time • Exams as percent of assignments • Has Peer Review • Has Programming • Has hands-on practice items
Item Characteristics	• Percent of exam questions with feedback • Median video length • Percent videos under 10 minutes • Percent videos with in-video questions (IVQs) • Has welcome video
Learning Objectives and Skills	• Percent of enrollments increasing skills • Skills taught in course • Percent of weeks with learning objectives • Percent of learning objectives advanced
Post-course Survey	• Avg satisfaction: instructor(s) • Avg satisfaction: videos • Avg satisfaction: programming • Avg satisfaction: exams • Avg satisfaction: peer reviews • Percent agree: right difficulty • Percent agree: right length • Percent agree: helpful feedback • Percent agree: sufficient practice

Data and Methods

CONTROL VARIABLES

Because of the vast diversity of courses and learners on Coursera, many potential confounding variables make it challenging to estimate some of these drivers' actual impact on the metrics of interest. Table 3 summaries the variables we control for when estimating the drivers' effects in Table 2. Course-level controls are generally variables that are fixed for a given instructor as they author a course. Enrollment-level controls are designed to capture inherent learner characteristics, which may influence the learner's ability to succeed but which are exogenous to the actual in-course learning process. We also include course-level drivers as controls in models meant to assess the impact of enrollment-level drivers, as they are generally fixed once a learner begins an enrollment. Definitions of each control variable can be found in Appendix A.

METHODOLOGY FOR IDENTIFYING EFFECTS

With a large set of control variables (including many that are categorical and require the specification of many levels), we use double-lasso[4] for principled covariate selection with a separate model for each driver to ensure that our estimate of its impact is as reliable as possible. Because we are analyzing each driver in its own model, we make a couple of key assumptions in order to compare their relative impact on the same scale.

First, we assume that all drivers have a linear, additive effect on the outcome metric when controlling for the selected covariates. This is often an over-simplification; nevertheless, it allows us to make relative comparisons between differently-distributed metrics much more easily. Second, we report the impact of each driver as the percent difference in model predictions when the driver variable is changed from its 25th percentile to its 75th percentile, holding all control variables at their means. This can effectively be thought of as the average impact a driver has on an outcome metric when it is changed from the lower end of its distribution to the higher end. We believe that these alterations fall in the range of reasonable actions that either instructors or learners can take to enhance the quality of the learning experience.

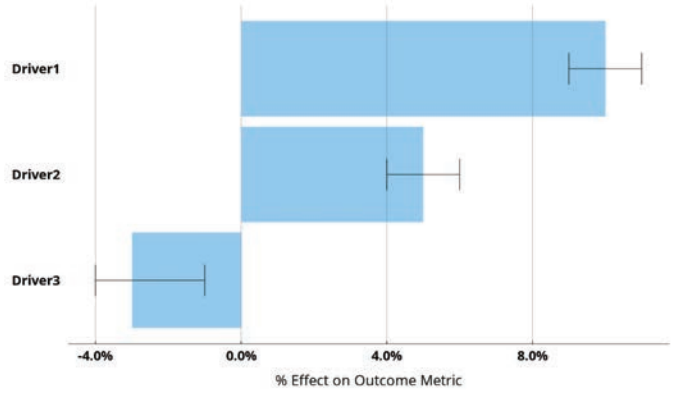
Throughout the next four sections, we report the effects of the most meaningful drivers in graphs in the form of Figure 0. The y-axis displays the names of each driver where there is a meaningful effect to report. The x-axis shows the effect of each driver on the measure of quality in question.

For example, *Driver1* in Figure 0 has a 10% "effect" on the outcome metric. In other words, using a statistical model for the outcome metric that incorporates *Driver1*, the average predictions when *Driver1* is set to its 25th percentile are 10% lower than the average predictions when *Driver1* is set to its 75th percentile. Graphs like Figure 0 help us understand the relative importance of different potential drivers, even when the drivers themselves have very different distributions and scales. To understand each figure more completely, you can find the actual 25th and 75th percentiles of each driver in Appendix A, and you can see which control variables are incorporated into each model in Appendix C.

TABLE 3. Control variables

Course-level Features	Enrollment-level Controls
• Course domain • Course subdomain • Tagged course difficulty level • Inferred course difficulty level • Course language • Is in specialization • Specialization rank • Is in certificate program • Historical course enrollments count • Historical partner enrollments count • Historical instructor enrollments count	• Previous enrollments (in domain) • Previous completions (in domain) • Enrollment type • Employment status • Level of education • Gender • Age • Country

FIGURE 0. Effects of drivers graphical template



4 To read further, see Urminsky, Hansen, and Chernozhukov https://home.uchicago.edu/ourminsky/Variable_Selection.pdf

How to Increase **Engagement**

coursera

Metric Overview

The first, mandatory step in a successful educational experience is for learners to engage with the course materials. Good engagement is the bare minimum for a high-quality course, and in order to reliably measure engagement, we use completion rates among the population of learners who are eligible to complete and are most likely to have a goal of course completion[5].

Figure 1A shows the distribution of completion rates separated by the type of enrollment. Clearly, the context of an enrollment has a large impact on the likelihood of that enrollment being completed. Among learners who have paid for access to the course, the average completion rate is 55.4%, however, there is wide variation across courses, with 25th and 75th percentiles of 43% and 69%, respectively. As we interpret which drivers matter most for completion rates, we will focus on "Paid" enrollments only, as learners in these enrollments have demonstrated the clearest intention to complete.

Figures 1B and 1C show how completion rates vary across subject area and course difficulty[6]. This demonstrates the importance of controlling for attributes of courses that are more or less fixed from an instructor's point of view when estimating the impact of our drivers of interest. Even within subject area and difficulty, however, we see substantial variation in completion rates, demonstrating the potential to impact this metric with proper course design.

FIGURE 1A. Course completion by type of enrollment

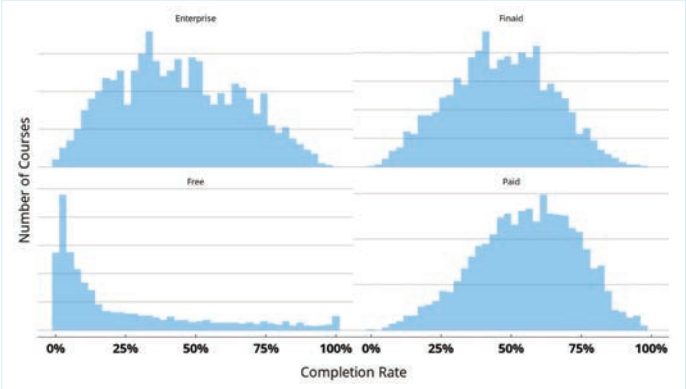


FIGURE 1B. Course completion by subject area

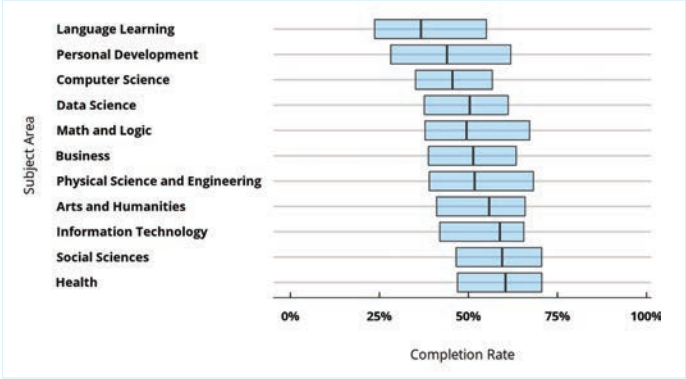
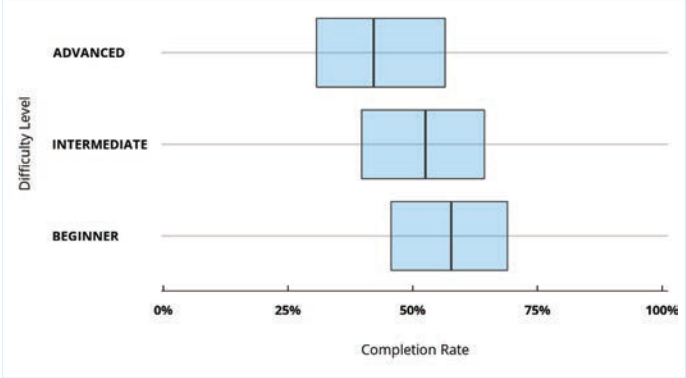


FIGURE 1C. Course completion by difficulty level



5 Although course materials on Coursera are always accessible free of charge, some learners are not eligible to complete courses unless they have paid for access, requested and received financial aid for the course, or are sponsored by their employer or another organization. In assessing the impact of drivers, we only consider learners who have paid for a course themselves.

6 We report course difficulty across three levels of Beginner, Intermediate, and Advanced. These levels are identified for each course on the platform using our skill scoring methodology. See Using a Glicko-based Algorithm to Measure In-Course Learning for more information.

Instructor Impact

Using the double-lasso covariate selection approach outlined in the Methodology section, we fit regression models for predicting completion rate using the course-level drivers and controls listed in Tables 2 and 3, respectively. Figure 2 demonstrates the average impact of moving the most meaningful drivers from the 25th percentile to the 75th percentile.

As an example, the bar for Number of Weeks shows that there is an 8% decrease in course completion associated with shifting the length of a course from 4 weeks (25th percentile course) to 6 weeks (75th percentile course), holding all else equal. Similarly, Hours per Week is also negatively related to average completion rate. This is largely unsurprising, as a larger volume of content places a heavier burden on learners. However, this serves as a good reminder that online content typically works best in smaller chunks, and designing courses that fit within 4 or 5 weeks is often prudent.

For content shorter than a month, one excellent delivery option on Coursera is the production of a Guided Project. Guided Projects can often be completed with just a few hours of learner investment and are optimized pedagogically for teaching hands-on skills to learners at a variety of levels. By focusing directly on the essential applications, Guided Projects allow both novice and advanced learners to create portfolio-relevant artifacts quickly and successfully.

If we control for course length, instructors can achieve a 2.5% average completion rate boost by designing courses with relatively longer first weeks of material (Relative Length of First Week). Although some courses tend to include an introductory week that is lighter on content (the 25th percentile first week is 43% as long as its course average), completion rates are higher for courses where week one is more substantial. The first week of a course is an audition, and a fuller first week may allow learners to experience learning gains earlier in the course, motivating their continued engagement.

Figure 2 also demonstrates that lower median video length can lead to 3.6% higher course completion rates. We can examine the mechanism of this effect more directly by observing lecture start-to-completion rates in Figure 3 (the proportion of learners starting a video who watch it to the end). Replacing longer videos with several videos under 10 minutes empowers learners to make progress in shorter batches. Online learning is optimized when it allows for flexibility in learning patterns, and shorter video lectures allow learners to better incorporate learning into their daily schedules.

In addition to the volume and length of content, course composition also plays an important role in determining course completion rates. Courses with more videos as a percent of total items and as a larger percent of total learning time achieve higher completion rates, on average. Learners are able to consume video lectures more passively than hands-on assignments, which makes moving through content less effortful. Similarly, we can see that Exams as percent of assignments can have a 12% effect on completion rates when moved from the 25th to 75th percentiles (10% and 94%, respectively). This is likely due to the fact that auto-graded exams are typically the easiest assignment option available to instructors, versus programming assignments or peer reviewed projects, which require greater investments of time and effort from learners. Although easier content and assignments can lead to higher completion rates, we will see in later sections that there may be a tradeoff between ease of completion and metrics like satisfaction and skill development.

FIGURE 2. Effects of instructor-driven course attributes on completion rate

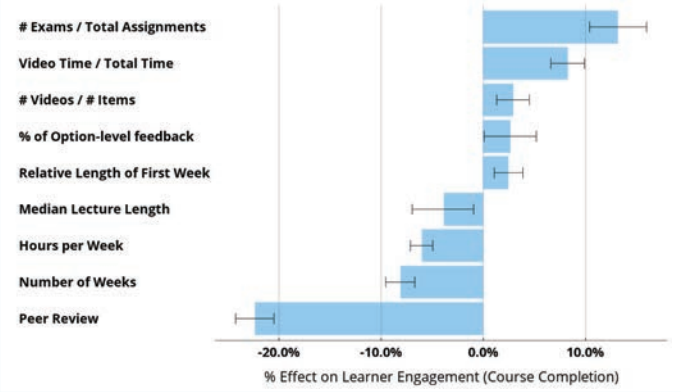
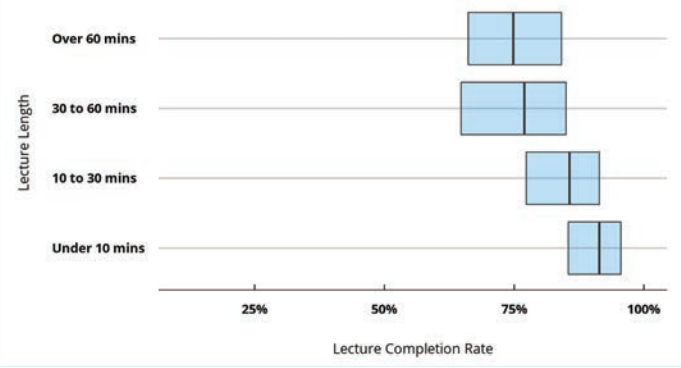


FIGURE 3. Percent of learners finishing videos that they start

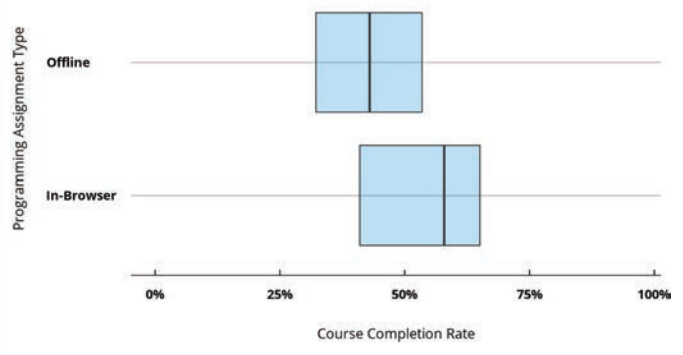


Instructor Impact

Regardless of the type of graded assignments used, there are certain best practices that can help optimize completion rates. One such example for exams is option-level feedback, explanations, and study tips that instructors may author for learners who answer exam questions incorrectly. The percent of exam questions with option-level feedback has a positive effect on completion rates, as feedback helps learners benefit from their mistakes and correct misunderstandings quickly.

In addition, although programming assignments are, on average, the most time-consuming assignment type for learners, instructors can improve the completion rates of these assignments by leveraging in-browser authoring options on Coursera. Figure 4 demonstrates that courses using in-browser programming assignments (like Coursera Labs[8]) have substantially higher completion rates than those that require students to download, install, and configure software and tools on their local machines. Coursera Labs not only remove much of the technical installation overhead for learners, but they are also much easier for instructors to create during authoring.

FIGURE 4. Course completion rates by the type of programming assignment used



Courses using in-browser programming assignments (like Coursera Labs) have substantially higher completion rates.

8 About Coursera Labs in Coursera's Partner Resource Center

Learner Impact

While instructors can boost average completion rates in their courses by adhering to the best practices outlined above, the successful completion of each enrollment is often determined by the motivations and behaviors of learners themselves. Even when we treat a learner's motivation and urgency as fixed, the flexibility and asynchronous nature of online courses grant learners great flexibility in how they choose to engage with their courses. One way to examine learning patterns is by leveraging clickstream data to determine when a learner is active in a particular course. We consider each distinct period of activity (separated by at least one hour between clicks) as a "learning session." Learning sessions allow us to quantify a learner's total time investment, as well as the frequency and regularity of their learning on the platform.

Figure 5 demonstrates the wide range of techniques that learners on Coursera use to successfully complete courses. Successful learners are often active anywhere from 1 to 5 days a week, but being active on a daily basis is also reasonably frequent (see spike at 7 learning sessions per week in Figure 5A). In addition, while most learners tend to learn in 40- to 60 minute blocks, it is not uncommon for learners to leverage much shorter or longer learning sessions while making progress toward completion. It is also interesting to note that these two distributions are fairly independent; while some learners complete courses with many short learning sessions spaced far apart, others complete with fewer, longer sessions in quick succession. Indeed, one of the benefits of online learning is that learners can find the strategies that work best for them and their schedules.

Despite the fact that learners can be successful with many different strategies, we are interested in understanding if certain behaviors are more related to successful engagement than others. To answer this question, we use the first two weeks of enrollment as an observational period and then examine which learning patterns over this period impact the likelihood of eventual completion of the course. Because learners can move through courses on Coursera at their own pace, we explicitly control for how much progress toward completion each learner makes (Progress on Graded Items) when evaluating the impact of other drivers. We also exclude the 13% of enrollments where learners complete the whole course in the two-week observational period. We can therefore evaluate these behaviors in terms of their effectiveness at causing future engagement, rather than their relationships to progress during the observational period.

Figure 6 depicts the types of learner behavior in the first two weeks of an enrollment that have the biggest impact on likelihood of course completion. The largest impact is a learner's Graded item progress. Learners who keep up with course deadlines are almost twice as likely to complete the course as learners who do not. This demonstrates the importance of investing early in a course to establish consistent habits that can be maintained during a learning journey that often lasts several weeks.

FIGURE 5A. Learning sessions by course completers per week

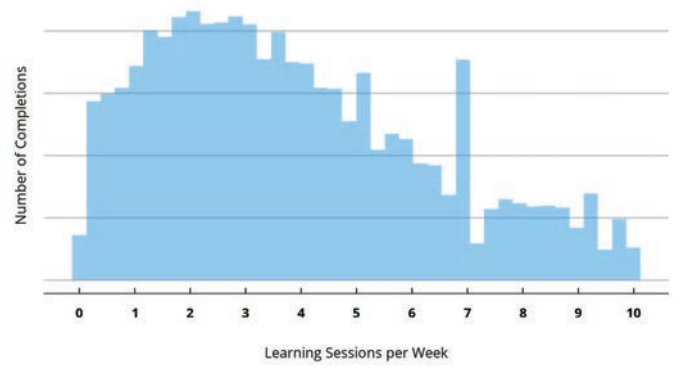


FIGURE 5B. Average length of learning sessions (MINs) by course completers

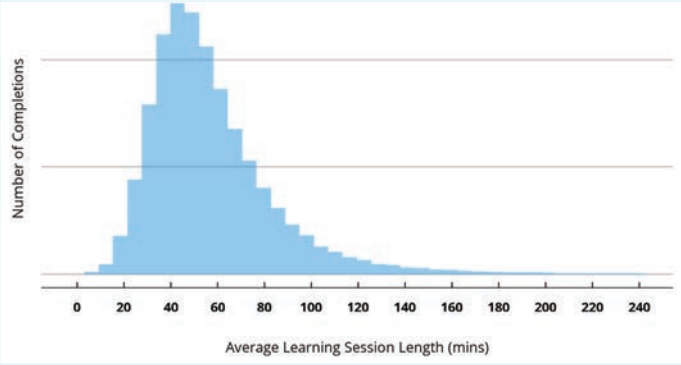
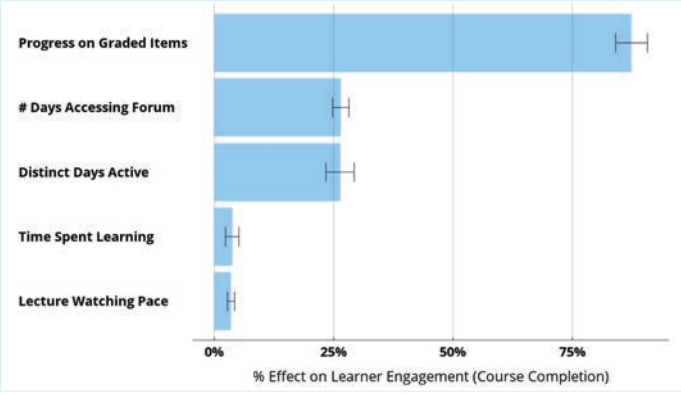


FIGURE 6. Effects of learner behavioral attributes on completion likelihood



Learner Impact

Although learners are free to adjust playback speeds and skip ahead in videos if they prefer, learners who spend relatively more time on lectures tend to complete courses at high rates. This is true even after controlling for learners with higher Time Spent Learning and lower Lecture Watching Pace. It shows that learners need not rush through material and instead may benefit from spending additional time to master topics, especially early in the course.

In addition to measures of total time invested, we also observe that Distinct Days Active can have a 25% increase in likelihood of completion. For a fixed amount of learning time, it is preferable for learners to spread their learning across more distinct days. This insight is key for understanding how learners should plan their learning schedule. Rather than wait for opportunities for multi-hour learning sessions, learners should focus on maintaining daily consistency, even if only shorter learning sessions are possible. Based on this insight, Coursera built an optional Goal Setting experience for learners who start new courses. Goal Setting lets learners to set a goal for how many days they wish to be active each week. Coursera helps hold them accountable by tracking their progress and allowing them to add learning schedules directly to their personal online calendars. Providing this option has significantly increased course completion rates in randomized trials.

The last finding highlighted in Figure 6 is the impact of social participation. Although discussion forums are not mandatory to complete most courses on Coursera, participating in them correlates with huge increases in completion likelihood. The magnitude of this impact is likely conflated with learner motivation and interest, but learners who participate in forums are over 25% more likely to complete courses, even controlling for all of the observable covariates at our disposal.

Learners who participate in forums are over 25% more likely to complete courses.

Takeaways

ACTIONABLE TAKEAWAYS FOR INSTRUCTORS

Right-size your course
Design course duration to be about 4 weeks

Use bite-sized videos
Limit lecture length to 10 minutes or less

Provide practice
Use in-browser programming assignments and Guided Projects for short-form, hands-on learning

Week one matters
Make sure it is robust enough for learners to experience tangible learning gains

ACTIONABLE TAKEAWAYS FOR LEARNERS

Don’t delay
Start learning immediately after enrolling in a course

Engage often
It’s more important to learn often than to learn for longer periods of time

Don’t rush
A more deliberate pace leads to more persistent engagement

Learn together
Forum participation makes it more likely that you’ll complete the course

How to Increase **Satisfaction**

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Metric Overview

Engagement in course material is the first priority for both instructors and learners. Conditional on engagement, we explore a more nuanced measure of course quality by analyzing the voice of the learner directly. Coursera employs several methods for collecting user feedback, and chief among them are course ratings. Learners are prompted to leave ratings upon finishing a course, so this analysis focuses on the population of learners who complete the course ("completers") before leaving a rating. Ratings are collected on a scale from 1 to 5 stars. Typical ratings of Coursera courses are extremely high: the platform-wide average is 4.7 stars, and 78% of learners rate their course a perfect 5 stars.

While this overall level of satisfaction is a good sign of the usefulness and quality of courses on Coursera, we remain interested in understanding what drives differences between the best courses and the rest. Because average ratings tend to be so high, we will focus on the proportion of ratings that are a perfect 5 stars for each course. Figure 7 shows the distribution of the percent of 5-star ratings among courses with at least 30 total ratings. The course-level average is 73%, with 25th and 75th percentiles of 67% and 82%, respectively.

When learners leave course ratings, they are also prompted to leave a free-text review. Although we will not dive into the specifics of these free-text reviews, Figure 8 provides an overview of the topics most frequently mentioned in an unstructured setting. With natural language processing techniques, we are able to identify common "topics" mentioned in reviews. The word cloud in Figure 8A displays some of the most commonly mentioned words associated with each topic, and the barplot in Figure 8B shows which topics are most commonly discussed by learners leaving different star ratings.

We can use the relative prevalence of different topics by rating as a crude measurement of which topics are most often associated with extremely positive or negative reviews. Learners leaving 5-star reviews are much more likely to mention "Instructors" and "Career Skills" than learners leaving less positive reviews. In addition, learners leaving 1-star to 3-star reviews are more likely to mention "Assignments," "Lectures," or something related to the "Time Commitment" of the course. We will not infer causality here, but this data provides valuable insight into what learners care about most.

FIGURE 7. Percent of 5-star ratings per course

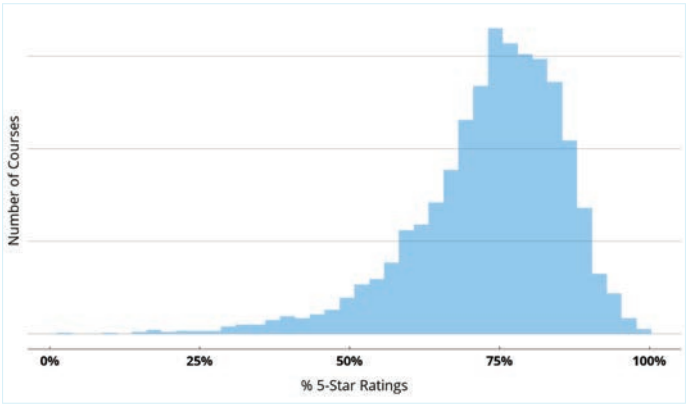
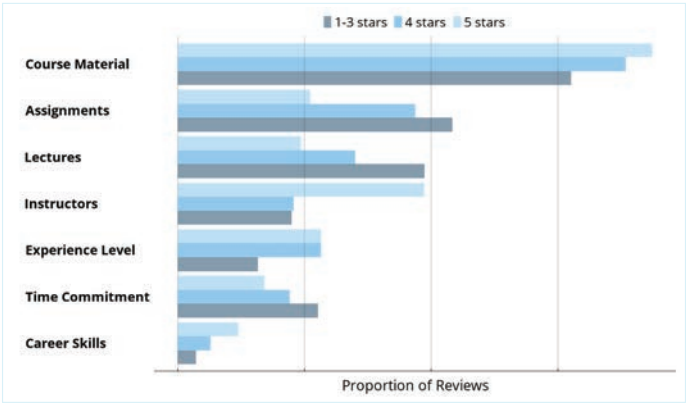


FIGURE 8A. Word cloud of most common phrases used in free-text reviews

FIGURE 8B. Course review topics by associated star rating



Instructor Impact

In order to assess what impact different instructor choices can have on learner satisfaction, we begin with the same list of course controls and potential drivers that we did in the previous section. We also control for the course's completion rate to combat the effects of survival bias[9].

Figure 9 shows the most substantial course-level drivers of satisfaction. Although longer courses tend to have lower completion rates, we find that both the Number of Weeks and the Items per Week have modest but meaningful positive impacts on the proportion of highly-satisfied completers. This is a good reminder that course length should be first and foremost dictated by the objectives of the content. If the content can be presented in a four- to five-week course, then that should remain the objective; however, longer courses do indeed produce more satisfied completers if the subject matter and learning goals call for that level of rigor.

Rigor remains a theme with the other drivers highlighted in Figure 9. Although we saw in the Engagement section that peer review and programming assignments do not increase completion rates, they do increase the satisfaction of completers. The lesson here is that learners value the opportunity to apply the concepts they are learning through hands-on assessments, even if they are more difficult than passive auto-graded exams.

The last insight to highlight in Figure 9 is the positive impact of Percent Exam Questions with Option-level Feedback. The presence of feedback is a rare driver that has a substantial positive impact on both engagement and satisfaction. Online learning can be frustrating when learners experience moments of failure with no guidance for what to do next. Turning mistakes into moments of learning is key to making asynchronous learning a positive experience.

When learners leave ratings and reviews for courses, they also have the opportunity to complete an optional survey that collects additional information on particular aspects of the course. In order to understand which features have the biggest impact on overall satisfaction, we fit a new model predicting the proportion of 5-star reviews using each measurement from the survey as a possible driver.

Figure 10 demonstrates the impact on overall satisfaction from moving subcomponent satisfaction scores from from the 25th to 75th percentiles. Not surprisingly, the strongest impacts come from satisfaction with instructors and videos, as the majority of content in most courses is delivered in the form of recorded videos that prominently feature the instructor. This is a big differentiator between the highest-rated and lowest-rated courses on the platform.

We can also observe that satisfaction with programming assignments is more important than satisfaction with other assignment types. In the computer science and data science domains, producing high-quality programming assignments is one of the most important investments for an instructor to make. Learners appreciate the opportunity for rigorous hands-on practice, and creating a high-quality experience (including using in-browser assignments) is paramount. Learners typically spend significantly longer on programming assignments than they do other assignment types on Coursera, and quality here does not go unnoticed.

FIGURE 9. Effects of instructor-driven course attributes on percent of 5-star reviews

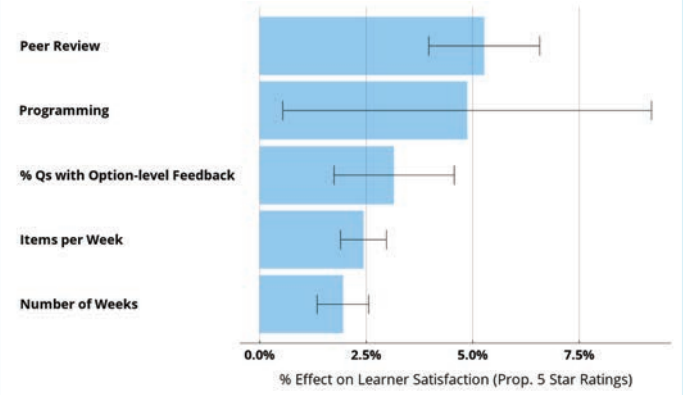
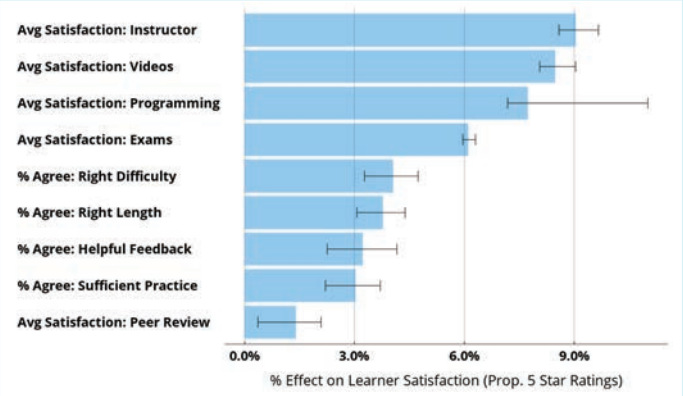


FIGURE 10. Effects of subcomponent satisfaction on overall percent of 5-star ratings



9 Survival bias represents the impact that the course funnel can have on measures of satisfaction at the end of the course. Because only the most dedicated learners complete difficult courses, we might expect these courses to have systematically higher levels of satisfaction. Although we would ideally collect feedback from both completers and non-completers, controlling for completion rate can help to alleviate this impact.

Takeaways

ACTIONABLE TAKEAWAYS FOR INSTRUCTORS

Create hands-on, substantial assignments

Learners prefer courses with peer reviewed projects and programming assignments that allow them to demonstrate what they've learned in a robust way

Give personalized feedback

Specific, targeted feedback on auto-graded exams helps learners benefit from mistakes without getting frustrated

Invest in your lectures

Satisfaction with videos and instructors is the most prominent driver of overall satisfaction

How to Increase **Skill Development**

coursera

Metric Overview

The immediate goal of many learners on Coursera is to gain new skills and refine existing ones. Using crowdsourced skill tags from instructors and learners, Coursera determines which skills are assessed by each graded assignment in the Business, Computer Science, Data Science, and Information Technology subject areas. Using a novel algorithm based on assessment performance[10], we measure skill attainment for learners across all of their enrollments on the platform. This allows us to directly observe the extent to which each course leads to skill development for the learners who enroll.

For new learners on the Coursera platform, there is a calibration period where the algorithm has a wide error range in predicting a learner's skill level. In our assessment of skill development, we therefore restrict our analysis to learners who have taken enough previous material for us to have an informed measure of their baseline skill level. This typically occurs after a learner has had at least 50 "attempts" across all assignments on the platform, the equivalent of completing about two courses, on average (about 10% of paid learners reach this threshold). Therefore, the findings in this section are based on a relatively small subset of enrollments where learners had sufficient prior experience on the platform; nevertheless, we believe these findings are generally relevant to all instructors and learners. See Appendix B for more details on how this subset of enrollments was selected.

Skill scores can be interpreted as the relative likelihood of a learner passing an assignment of a certain difficulty level; for example, a learner with a skill score of 3 is three times more likely to pass an assignment than a learner with a skill score of 1. For all relevant enrollments, we compute the "Score Delta" as the difference in the learner's skill score from the beginning of the course to the end of the last graded assignment. Figure 11A shows the wide range of initial skill scores for users at the beginning of their courses, even among the population with stabilized estimates. In Figure 11B, we also observe that although the Score Delta can be negative — in cases where learners fail assignments they would be expected to pass — it is often far more positive as learners gain skills through practice. Learners with score deltas near 0 often do not attempt many assessments or perform at a level corresponding to their prior skill score.

FIGURE 11A. Distributions of initial skill scores and Score Deltas

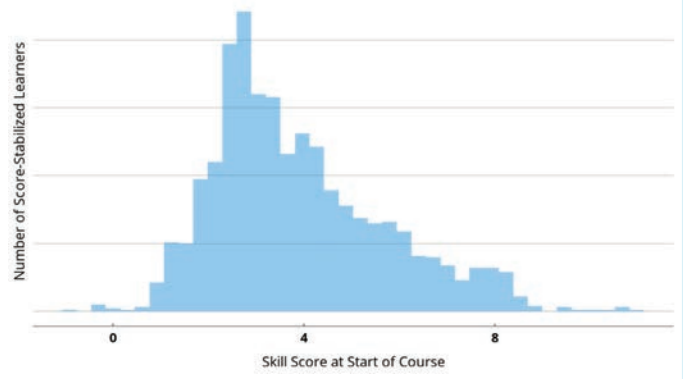
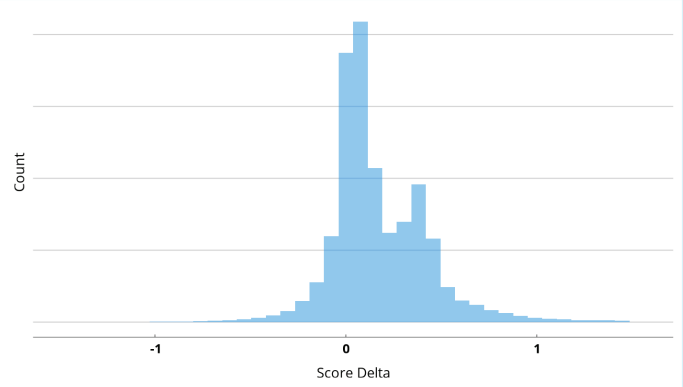


FIGURE 11B. Score Delta - the change in skill score from start to finish



10 Using a Glicko-based Algorithm to Measure In-Course Learning

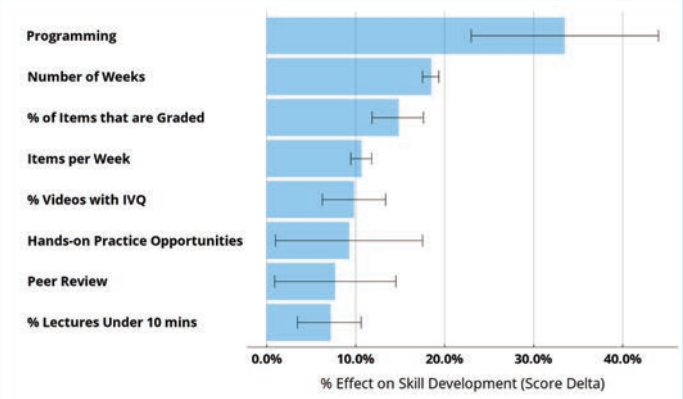
Instructor Impact

Figure 12 displays the most meaningful instructor drivers of skill development identified with double-lasso regression. Perhaps unsurprisingly, course length, both in terms of the Number of Weeks and Items per Week, is associated with higher skill development. In addition, we see that having a higher percent of videos under 10 minutes leads to more skill development. Shorter videos allow learners to chunk content more easily, which can facilitate review of course concepts and therefore improve assessment performance. It's also important to provide learners with ample opportunities to demonstrate the new skills they are learning, as shown by the substantial positive effect of having a higher percent of items that are graded.

Skill development is also driven by opportunities for lower-stakes practice. Both the percent of videos with in-video questions and the presence of hands-on practice items increase average skill development by almost 10%. These strategies give learners chances to practice new skills in a low-stakes environment where grades and skill scores are not impacted, allowing them to make mistakes and see feedback without the unpleasant experience of failing an assignment.

The final trend highlighted in Figure 12 is the importance of robust, authentic assessments. The presence of Peer Review and Programming assignments are associated with large increases in average skill development. Whereas auto-graded exams are good opportunities to check understanding, real skill development in all subject areas — and especially technical domains — often requires learners to apply new skills in real-world settings. We see this clearly reflected in the fact that including programming assignments leads to a more than 30% increase in skill development in Computer Science and Data Science courses.

FIGURE 12. Effects of instructor-driven attributes on average skill score delta



Videos with in-video questions and hands-on practice items each increase average skill development by almost 10%.

Learner Impact

Figure 13 displays the effects of various learner-controlled drivers on skill development. First and foremost, we see that choosing the right course is critically important. Learners who select courses with higher Relative Course Difficulty — more challenging compared to their initial skill level — have the opportunity to gain 200% more skill development than learners who enroll in courses that are easy relative to their current level.

Because selecting the right course has such a significant impact on skill gains, we take a closer look at the relationship between Relative Course Difficulty and Score Delta in Figure 14. The curve illustrates a clear threshold that differentiates enrollments with high skill development from those with low skill development. Although higher relative difficulty in general leads to larger gains in skills, there is a key inflection point at 0, when assignments are at least as advanced as a learner's initial skill level. Finding courses that are challenging but at an achievable level is the key for learners to increase their skills quickly. To help in this endeavor, Coursera offers Career Learning Paths[11], which can provide substantial guidance to learners seeking to find the optimal courses for their goals and current level.

Conditional on choosing a course that is appropriately challenging and completing the required assignments, we also see that learners who spend more time with the optional content in their courses tend to have higher skill development. Although learners are able to complete courses without completing all of the ungraded items, learners with higher Percent of Videos Completed and Percent of Ungraded Items Completed tend to perform better on assignments and achieve higher increases in skill scores. A related finding shows learners can increase their skill development with a higher frequency of learning, as demonstrated by the substantial positive effects from increasing Days Active and Learning Sessions. Even controlling for the length of a course, learning frequently and consistently on as many days as possible is beneficial for accelerating skill development in the process of completing a course.

FIGURE 13. Effects of learner behaviors on average skill score delta

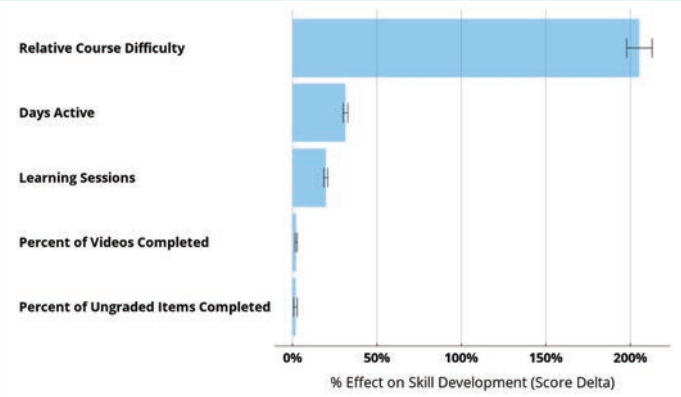
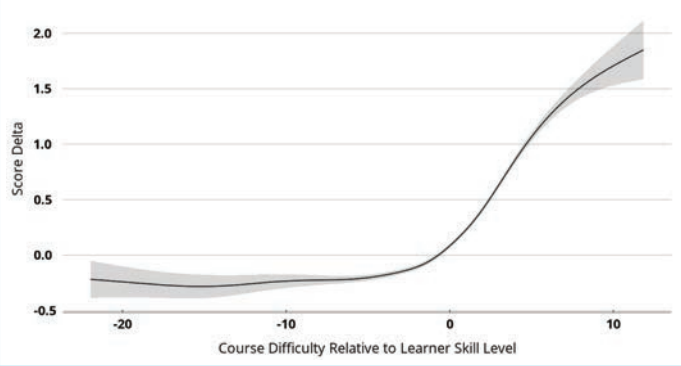


FIGURE 14. Relative course difficulty vs. skill score delta



Learners who select courses with higher relative difficulty have the opportunity to gain 200% more skill development.

11 See additional information about Career Learning Paths

Takeaways

ACTIONABLE TAKEAWAYS FOR INSTRUCTORS

Provide hands-on practice

Let learners apply knowledge using real-world tools in low-stakes environments

Test often

Rigorous, frequent assessments allow learners to solidify their knowledge and demonstrate what they have learned

Use bite-sized lectures

Shorter lectures make it easier for learners to progress, review content, and perform well on assessments

ACTIONABLE TAKEAWAYS FOR LEARNERS

Challenge yourself, appropriately

Don't go for material that is too easy or too hard; Career Learning Paths can help you find the right fit

Develop a habit

Frequent and consistent learning patterns lead to more efficient skill gains

Be thorough

Completing all ungraded material carefully leads to better skill development

How to Increase **Career Outcomes**

coursera

Metric Overview

Generally, the goal of education is to help learners achieve their career aspirations. This is especially true on Coursera, where 63% of course completers state that they have a career-related objective to either advance in their current career or start a new career.

To better understand how instructors can design their courses to maximize the potential career impact on learners, we leverage data from Coursera's Learner Outcomes Survey. This survey, which has been running since 2016, has over 100,000 responses from course completers on how online learning has transformed their lives. Six months after completing a course, learners are asked to self-report any career outcome related to the course. This survey captures specific outcomes across various dimensions, including pay increases, promotions, finding a new job, becoming better at a current job, starting a business, picking a new career path, and improving candidacy for new positions. Learners can select none or any number of these options, depending on the results they have experienced since completing the course.

As a baseline, 73% of course completers currently report a career outcome by selecting at least one of the above options. Figure 15 shows what this distribution looks like across courses on the platform where we have at least 25 responses to the Learner Outcomes Survey. While the majority of courses show high rates of career outcomes, there is substantial variation across courses with 25th and 75th percentiles of 61% and 86%, respectively, suggesting that instructors can meaningfully affect career outcome rates by adjusting their content.

In terms of fixed course attributes, Figure 16 shows there is substantial variation in career outcome rates across subject areas. Learners in courses with a direct mapping to careers are generally more likely to report outcomes. For instance, over 80% of course completers in Business, Data Science, Information Technology, and Computer Science report career outcome.

These differences by subject area suggest one of the most impactful things instructors can do is to ensure their courses are career relevant, teaching the skills most desired by employers. To that end, Coursera's content strategy team routinely consults with instructors on what skills to include in their content, drawing upon their own expertise and three central sources of information: (1) on-platform data on what learners in various careers are taking, (2) off-platform research on in-demand skills from job postings, and (3) feedback from our many enterprise customers on what skills they are looking for in new hires.

As demonstrated by Figure 17, a learner's home country also dramatically affects the likelihood of reporting a career outcome. Generally, learners located in Africa, South America, and Asia are more likely to report a career impact than learners in Europe, North America, and Oceania.

FIGURE 15. Percent of course completers citing a positive career outcome

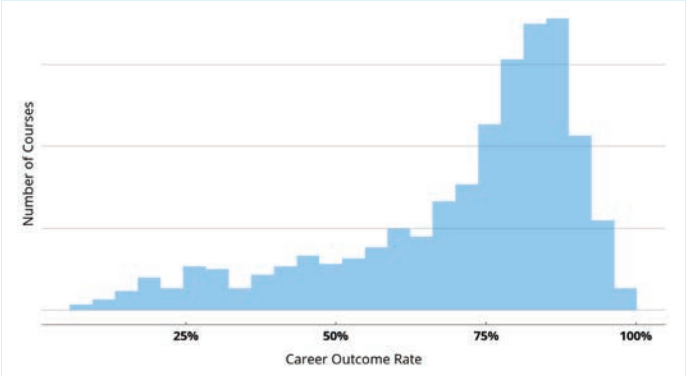


FIGURE 16. Career outcome rate by subject area

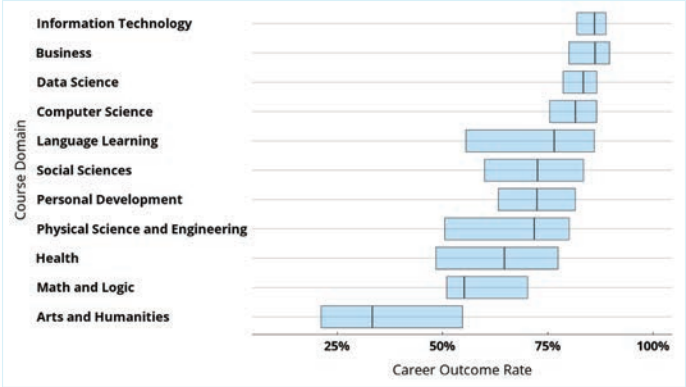
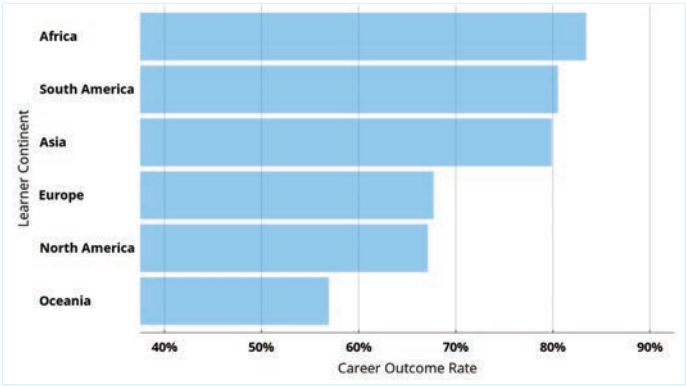


FIGURE 17. Career outcome rate by learner home continent



Instructor Impact

While subject area and learner location are two factors typically outside of instructors' control, we can also examine the impact on career outcome rates of course features they do control. To identify the most influential factors, we follow the approach outlined in the Methodology section by predicting the likelihood a learner reports a career outcome using the drivers and controls listed in Tables 2 and 3. In addition, we include two new drivers related to skill development (Proportion Enrollments Increasing Skills and Count of Skills Taught in Course) to understand how skill development stacks into career outcomes. Figure 18 demonstrates the average impact of moving each significant driver from the 25th percentile to the 75th percentile of courses.

Several factors stand out in Figure 18. First, the amount and depth of skill development matters. Higher Skills taught in course and Percent of enrollments increasing skills both lead to more frequent career outcomes. One way for instructors to maximize these factors is to create Professional Certificates, which are designed to equip learners with all the essential skills for a career and assume no prior knowledge or experience. These certificates allow learners to go from zero background to being job ready by the end of the program, and tend to have some of the highest career outcome rates.

Second, we observe the impact of learning objectives on career outcomes. Learning objectives are descriptions of what learners should take away from each section of material, and instructors can optionally attach learning objectives to eachcourse "module" — the main unit of content, typically covering one week. Learning objectives are phrased in terms of Bloom's taxonomy — a standard hierarchy for assessing the depth of learning. The first two levels, (1) remember and (2) understand, are passive in nature and typically represent mastering basic concepts. Levels three and above, (3) apply, (4) evaluate, (5) analyze, and (6) create, are active in nature, and require learners to use concepts in new situations and incorporate multi-step processes, decision making, and creativity. Figure 18 shows that having a higher percent of modules with learning objectives and a percent of learning objectives Level 3+ both lead to superior rates of career outcomes. Learning objectives make outcomes more explicit during course design, and focusing on more in-depth objectives forces learners to apply the skills they learn in ways more analogous to how they will use them in actual career settings.

Indeed, beyond designing active learning into the objectives of courses, instructors can also affect career impact by providing applied assignments. Courses with higher proportions of peer review and programming assignments as percent of assignments — in lieu of having only automatically-graded exams — are associated with higher career outcome rates. It is essential to allow learners to build their skills through assignments that let them practice in authentic settings.

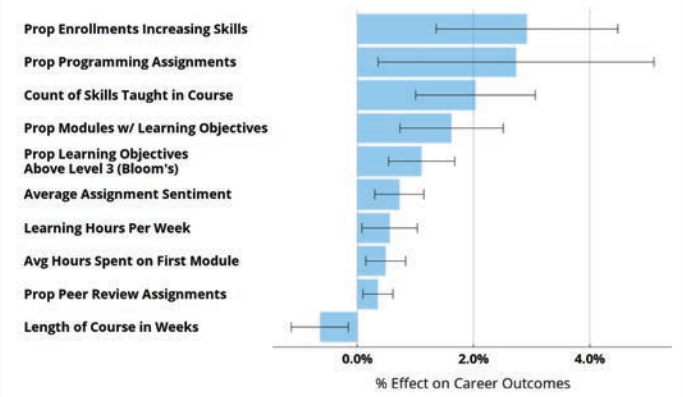
The quality of these assignments is also important: higher average assignment satisfaction drives increased rates of career outcomes as well.

As mentioned earlier, Guided Projects are a natural format for providing opportunities for learners to practice with hands-on applications. Because instructors can create a nuanced virtual environment for learners to access, aligning projects with job-relevant software tools and contexts is highly achievable. This allows instructors to capture the value of both applied assignments and higher-level learning objectives.

The last important factors highlighted in Figure 18 are related to the length of the course. The positive effects on career outcomes from Learning time per week and Learning time week 1 vs. avg week highlight the importance of having robust content each week, especially early on as learners are easing into the content. Learning skills valuable enough to make an impact on one's career often requires substantial time, and instructors should focus on teaching each weekly topic in depth even if it increases the time learners must spend.

To summarize, online learners are often looking for a positive career impact. The majority either want to break into a new career or advance further in their current career. Therefore, designing courses for maximal career relevance should be an important goal for instructors if they want to appeal to learner demand. To facilitate this, instructors should focus on creating content with high-quality learning objectives that map to the higher levels of Bloom's taxonomy and teach job-relevant skills using high-quality, applied assignments. These assignments should focus on allowing learners to develop a broad range of skills in sufficient depth to meet labor-market demands. The course content itself should also be designed specifically for online, ensuring a modularized structure to promote engagement, satisfaction, and skill development.

FIGURE 18. Effects of instructor-driven attributes on career outcome rate



Takeaways

ACTIONABLE TAKEAWAYS FOR INSTRUCTORS

Skills pay the bills
Make sure your course teaches high-demand job skills

Set clear goals for learners
Ensure learning objectives clearly develop the skills employers want

Make them prove it
Rigorous, authentic assignments are what employers look for as proof that a learner has mastered relevant skills

Don’t shy away from depth
Learners must spend substantial time on each topic to gain a true career outcome

Next Steps

The goal of this report is to elucidate the drivers of online learning success so that we can reach even higher levels of quality in the future. For both instructors and learners, there are many actionable lessons that we can glean from this plethora of data.

As the world continues to use online teaching more than ever before, we will be analyzing what works best for whom to create the strongest educational experiences possible.

Appendix

APPENDIX A

Datasets and Variable Definitions

TABLE A1. Datasets for Each Quality Metric

For each of the four key metrics of quality, we use a dataset that allows us to analyze the distributions and drivers without necessitating small sample size corrections. All datasets pull from enrollments that began between Jan 1, 2016 and Dec 31, 2019.

Metric	DATASET(S)
Completion Rate	Course-level: 2,583 courses with at least 100 paid enrollments **Variable of interest:** Completion rate Enrollment-level: 5.0 million paid enrollments **Variable of interest:** Likelihood of completion
Proportion of 5-star Reviews	Course-level: 3,412 courses with at least 30 course feedback ratings **Variable of interest:** Proportion of 5-star reviews
Skill Development	Enrollment-level: 260k completed enrollments with reliable pre-course skill scores, in relevant subject areas **Variable of interest:** Increase in skill scores from start to completion
Career Outcomes	Enrollment-level: 100k course completers responding to the Learner Outcome Survey who cite career goals **Variable of interest:** Indicated career outcome attributed to course completion

TABLE A2. Instructor Drivers

This is the full list of instructor-driven attributes considered in our analyses. All are defined at the course level. This table categorizes these attributes for ease of understanding, and also lists the definition and the 25th and 75th percentiles (used to calculate the "Effect" of these drivers on metrics of quality, as described in *Data and Methodology*).

Category	Label	Definition	25th %ile	75th %ile
Course Length	Number of weeks	Number of weeks of content that a learner must complete	4	6
	Learning time per week	Average number of hours spent by learners to complete each week of content	2.3	4.4
	Learning time week 1 vs. avg week	Average learning time in week one divided by the average learning time per week	0.45	1.15
	Items per week	Average number of items (lectures, readings, assignments, etc.) in each week of content	10	18
Course Composition	Videos as percent of items	The share of items that are videos	43%	70%
	Videos as percent of learning time	The average share of learning time spent on videos	23%	48%
	Assignments as percent of items	The share of items that are graded	8%	17%
	Exams as percent of assignments	The share of graded items that are quizzes and exams	10%	94%
	Has Peer Review	0 or 1 signalling the presence of graded peer review items	0	1
	Peer review as percent of assignments	The share of graded items that are peer reviewed projects		
	Has Programming	0 or 1 signalling the presence of graded programming items	0	1

APPENDIX A

Datasets and Variable Definitions

TABLE A2. Instructor Drivers (cont.)

Category	Label	Definition	25th %ile	75th %ile
Course Composition	Programming as percent of assignments	The share of graded items that are programming assignments		
	Has hands-on practice items	0 or 1 signalling the presence of ungraded hands-on practice opportunities (notebooks, plugins, discussion prompts, etc.)	0	1
Item Characteristics	Percent of exam questions with feedback	Percent of exam questions where the instructor provides option-level feedback to help learners who answer incorrectly	0%	94%
	Median video length	Median video length of all videos in the course	6	15
	Percent videos under 10 minutes	Percent of videos under 10 minutes in length	33%	62%
	Percent videos with in-video questions	Percent of videos that include at least one in-video question to test student comprehension	0%	56%
	Has welcome video	0 or 1 signalling the presence of a welcome video before content videos	0	1
Learning Objectives and Skills	Percent of enrollments increasing skills	Percent of learners who increase their skill proficiency by completing the course	0%	78%
	Skills taught in course	The number of distinct skills tagged to the course by instructors or learners	0	3
	Percent of modules with learning objectives	Percent of modules of content where the instructor wrote learning objectives	0%	100%
	Percent of learning objectives Level 3+	Percent of learning objectives geared toward applying, evaluating and analyzing (rather than remembering and understanding)	0%	39%
Post-Course Survey	Avg satisfaction: instructor(s)	Average satisfaction (1-5 scale) from post-course survey respondents	4.60	4.84
	Avg satisfaction: videos	Average satisfaction (1-5 scale) from post-course survey respondents	4.55	4.78
	Avg satisfaction: programming	Average satisfaction (1-5 scale) from post-course survey respondents	4.38	4.66
	Avg satisfaction: exams	Average satisfaction (1-5 scale) from post-course survey respondents	4.41	4.63
	Avg satisfaction: peer reviews	Average satisfaction (1-5 scale) from post-course survey respondents	4.25	4.48
	Avg satisfaction: assignments	Weighted average of the three previous satisfaction scores, weighted by the number of assignments of each type in the course	4.39	4.62
	Percent agree: right difficulty	Proportion of post-course survey respondents who agree that the course is at the right difficulty	78%	88%
	Percent agree: right length	Proportion of post-course survey respondents who agree that the course is the right length	75%	85%
	Percent agree: helpful feedback	Proportion of post-course survey respondents who agree that the course has helpful feedback	25%	37%
	Percent agree: sufficient practice	Proportion of post-course survey respondents who agree that the course provides sufficient practice opportunities	83%	92%

APPENDIX A

Datasets and Variable Definitions

TABLE A3. Learner Drivers

This is the full list of learner-driven attributes considered in our analyses. All are defined at the enrollment level (user+course pair). This table categorizes these attributes for ease of understanding, and also lists the definition and the 25th and 75th percentiles (used to calculate the "Effect" of these drivers on metrics of quality, as described in Data and Methodology).

Category	Label	Definition	25th %ile	75th %ile
Course Progress	Graded item progress	Number of graded items completed divided by the number of graded items due to date, measured 14 days after enrollment	0%	100%
	Percent of videos completed	The percent of videos in the course completed by the learner, measured for completed enrollments	85%	100%
	Percent of ungraded items completed	The percent of ungraded items in the course completed by the learner, measured for completed enrollments	74%	96%
Learning Patterns	Time spent learning	Total hours spent learning, measured 14 days after enrollment	0.45	6.5
	Learning sessions	Number of distinct learning sessions (separated by at least 1 hour of inactivity), measured 14 days after enrollment / upon completion	1 / 6	4 / 21
	Days active	Number of distinct days on which a learner completed at least one item in the course, measured 14 days after enrollment / upon completion	1 / 4	3 / 12
	Video watching pace	Time spent watching videos divided by the total length of videos watched	0.60	0.95
Social Learning	Days accessing forum	Number of distinct days on which a learner accessed the forums associated with the course	0	2
	Is Forum Participant	Indicator of whether the learner initiated a forum thread or left a response on an existing forum thread, measured 14 days after enrollment initiated or responses left in the course forums	0	1
Course Choice	Relative course difficulty	Difference between a learner's initial skill proficiency score and the median graded item difficulty	-1.18	0.95

APPENDIX B

Skill Development Learner Details

For new learners on the Coursera platform, we often observe monotonic skill increases as their behavior reveals the skills and competencies they learned before enrolling in their first Coursera course, since learners start at a default score of 0. In order to separate the skill score increases that are a result of the algorithm calibrating to a learner's baseline skills, we only consider learners whose skill scores have already "stabilized". Figure B1 shows that this stabilization occurs roughly after 40 attempts of graded items. In this paper, we focus on learners who have attempted 50 graded items to ensure they are well past the threshold where we would consider them to still be demonstrating previously acquired skills.

For this reason, the findings in the How to Increase Skill Development section the findings in the How to Increase Skill Development section apply only to a subset of our full learner base, and that subset is not representative of all learners in some key ways. Figure B2 shows that learners with stable skill scores are learners who take most of their courses in the Business, Computer Science, and Data Science domains, with Data Science learners accounting for 60% of all stable score enrollments but only roughly 30% of all other enrollments. Figure B3 shows that learners with a stable skill score tend to have joined earlier than the entire population of learners on Coursera's platform. Newer learners typically have not had as much time to attempt a sufficient number of assignments to demonstrate their pre-existing knowledge.

FIGURE B1. Average skill score vs. assessment attempt index

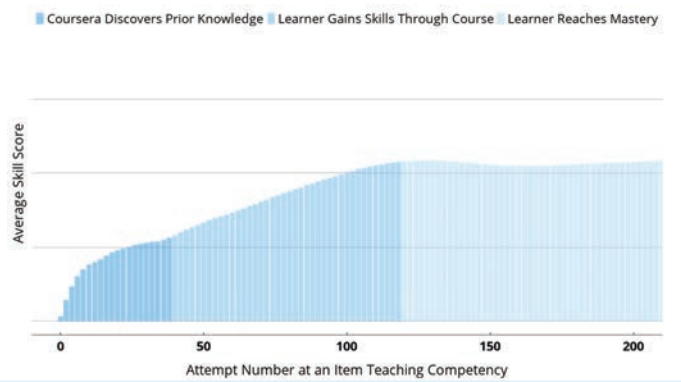


FIGURE B2. Subject areas of enrollments for learners with stable skill scores vs. those without stable skill scores

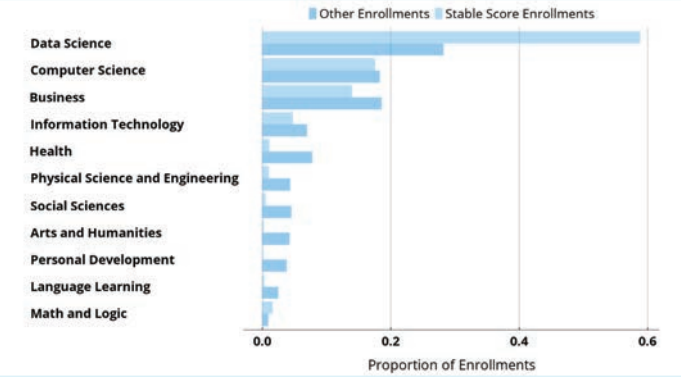
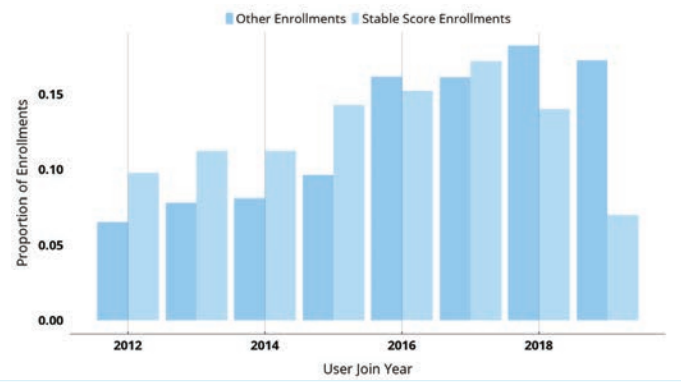


FIGURE B3. Year of Coursera registration for learners with stable skill scores vs. those without stable skill scores



APPENDIX C

Detailed Regression Tables

The following tables show which controls were considered when constructing models that estimate all of the effects displayed in the report. Although each control variable indicated was considered during the double-lasso selection process defined in the Methodology section, not all were necessarily included in the final statistical model used to evaluate the Effect of each driver.

ENGAGEMENT

TABLE C1. Instructor drivers (as displayed in Figure 2)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Number of weeks	*		All courses	
Learning time per week	*		All courses	Number of weeks
Learning time week 1 vs. avg week	*		All courses	", Learning time per week
Videos as percent of items	*		All courses	"
Videos as percent of learning time	*		All courses	"
Exams as percent of assignments	*		All courses	"
Has Peer Review	*		All courses	"
Median video length	*		All courses	Number of weeks, Learning time per week, Learning time week 1 vs. avg week, Videos as percent of items, Videos as percent of learning time, Exams as percent of assignments, Has Peer Review, Has Programming
Percent of exam questions with feedback	*		Courses with at least 10 exam questions	", Number of exam questions

TABLE C2. Learner drivers (as displayed in Figure 6)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Graded item progress	*	*	All enrollments incomplete after 2 weeks	
Time spent learning	*	*	"	Graded item progress
Days active	*	*	"	Graded item progress, Time spent learning
Video watching pace	*	*	"	Graded item progress, Time spent learning, Days active
Days accessing forum	*	*	"	Graded item progress, Time spent learning, Days active, Video watching pace, Presence of Discussion prompt item

APPENDIX C

Detailed Regression Tables

SATISFACTION

TABLE C3. Instructor drivers (as displayed in Figure 9, Figure 10)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Number of weeks	*		All courses	
Items per week	*		All courses	Number of weeks
Has Peer Review	*		All courses	Number of weeks, Items per week
Has Programming	*		Data Science and Computer Science courses	Number of weeks, Items per week
Percent of exam questions with feedback	*		Courses with at least 10 exam questions	Number of weeks, Items per week, Number of exam questions
Subcomponent Satisfaction	*		All courses with 20+ responses to post-course survey	Number of weeks, Items per week, Has Peer Review, Has Programming, Percent of exam questions with feedback

SKILL DEVELOPMENT

TABLE C4. Instructor drivers (as displayed in Figure 12)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Number of weeks	*		All courses	
Items per week	*		All courses	Number of weeks
Has Peer Review	*		All courses	Number of weeks, Items per week
Has Programming	*		Data Science and Computer Science courses	Number of weeks, Items per week
Assignments as percent of items	*		All courses	Number of weeks, Items per week
Has hands-on practice items	*		All courses	Number of weeks, Items per week, Has Peer Review, Has Programming, Assignments as percent of items
Percent videos under 10 minutes	*		All courses	Number of weeks, Items per week, Has Peer Review, Has Programming, Assignments as percent of items, Has hands-on practice items
Percent videos with in-video questions	*		All courses	Number of weeks, Items per week, Has Peer Review, Has Programming, Assignments as percent of items, Has hands-on practice items, Percent videos under 10 minutes

APPENDIX C

Detailed Regression Tables

SKILL DEVELOPMENT

TABLE C5. Learner drivers (as displayed in Figure 13)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Relative course difficulty	*	*	All completed enrollments	
Days active	*	*	"	Relative course difficulty, Time spent learning
Learning sessions	*	*	"	Relative course difficulty, Time spent learning, Days active
Percent of videos completed	*	*	"	Relative course difficulty, Time spent learning, Days active, Learning sessions
Percent of ungraded items completed	*	*	"	Relative course difficulty, Time spent learning, Days active, Learning sessions

CAREER OUTCOMES

TABLE C6. Instructor drivers (as displayed in Figure 18)

Driver	Course-level Controls (Table A4)	Learner-level Controls (Table A5)	Subset of Dataset	Other Controls considered
Learning time per week	*		All courses	Number of weeks
Learning time week 1 vs. avg week	*		All courses	Number of weeks, Learning time per week
Peer Review as percent of assignments	*		All courses	Number of weeks, Learning time per week, Learning time week 1 vs. avg week
Programming as percent of assignments	*		Data Science and Computer Science courses	Number of weeks, Learning time per week, Learning time week 1 vs. avg week
Avg satisfaction: assignments	*		All courses	Number of weeks, Learning time per week, Learning time week 1 vs. avg week, Peer Review as percent of assignments, Programming as percent of assignments
Skills taught in course	*		All courses	Number of weeks, Learning time per week, Learning time week 1 vs. avg week, Peer Review as percent of assignments, Programming as percent of assignments, Avg satisfaction: assignments
Percent of modules with learning objectives	*		All courses	"
Percent of learning objectives Level 3+	*		All courses with learning objectives	"
Percent of enrollments increasing skills	*		All courses with at least one skill tagged	"

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