NBER WORKING PAPER SERIES

DOES CLASSROOM TIME MATTER? A RANDOMIZED FIELD EXPERIMENT OF HYBRID AND TRADITIONAL LECTURE FORMATS IN ECONOMICS

Theodore J. Joyce
Sean Crockett
David A. Jaeger
Onur Altindag
Stephen D. O'Connell

Working Paper 20006
http://www.nber.org/papers/w20006

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2014

The authors thank participants at the Ausschuss für Bevölkerungökomik 2014 conference in Linz and seminar participants at the CUNY Graduate Center and Queens College for helpful comments. Jaeger and Joyce acknowledge support from a CUNY Collaborative Incentive Research Grant (CIRG), Round 20. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Does Classroom Time Matter? A Randomized Field Experiment of Hybrid and Traditional Lecture Formats in Economics
Theodore J. Joyce, Sean Crockett, David A. Jaeger, Onur Altindag, and Stephen D. O'Connell
NBER Working Paper No. 20006
March 2014
JEL No. I20,I23

ABSTRACT

We test whether students in a hybrid format of introductory microeconomics, which met once per week, performed as well as students in a traditional lecture format of the same class, which met twice per week. We randomized 725 students at a large, urban public university into the two formats, and unlike past studies, had a very high participation rate of 96 percent. Two experienced professors taught one section of each format, and students in both formats had access to the same online materials. We find that students in the traditional format scored 2.3 percentage points more on a 100-point scale on the combined midterm and final. There were no differences between formats in non-cognitive effort (attendance, time spent with online materials) nor in withdrawal from the class. Comparing our experimental estimates of the effect of attendance with non-experimental estimates using only students in the traditional format, we find that the non-experimental were 2.5 times larger, suggesting that the large effects of attending lectures found in the previous literature are likely due to selection bias. Overall our results suggest that hybrid classes may offer a cost effective alternative to traditional lectures while having a small impact on student performance.

Theodore J. Joyce
NBER
5 Hanover Square, 16th Floor
Suite 1602
New York, NY 10004-2630
theodore.joyce@baruch.cuny.edu

Sean Crockett
Baruch College
Department of Economics and Finance
55 Lexington Avenue
New York, NY 10010
Sean.Crockett@baruch.cuny.edu

David A. Jaeger
NBER
5 Hanover Square, 16th Floor
Suite 1602
New York, NY 10004-2630
djaeger@gc.cuny.edu

Onur Altindag
NBER
5 Hanover Square, 16th Floor
Suite 1602
New York, NY 10004-2630
ronuraltindag@gmail.com

Stephen D. O'Connell
City University of New York
Department of Economics
The Graduate Center
365 Fifth Ave
New York, NY 10016-4309
soconnell@gc.cuny.edu

James A. Garfield, twentieth president of the United States and a graduate of Williams College, is reputed once to have said of renowned educator Mark Hopkins: “the ideal college is Mark Hopkins on one end of a log and a student on the other” (Rudolf, 1956, p. vii). Garfield's epigram embodies the notion that the best learning takes place in a dialogue between student and professor, in which students take an active role in the learning process and professors can easily gauge a student's comprehension through verbal and non-verbal cues. This ideal remains at the core of American higher education despite the enormous changes in instructional technology that have occurred since the mid-19th century when Garfield was educated. In the mid 1950's, television was the first technology to capture the imagination of university administrators keen to reach a larger student population and, most importantly, hold the costs of instruction down (Macmitchell 1955; Eurich 1958). Most recently, the Internet and various modes of online instruction have captured the imaginations of university administrators anxious to cut costs -- particularly courses taught online to tens of thousands or hundreds of thousands of students, so-called massive open online courses, or MOOCs – despite being the diametric opposites of Garfield’s “log” ideal. Although the initial excitement over MOOCs has diminished somewhat due to questions of completion rates and efficacy (Collins, 2013; Lewin, 2013), and the fact that MOOCs are completed primarily by college graduates (Ho et al. 2014), online learning in some form will surely be an increasingly important component of university education, even potentially improving on the kind of instruction Mark Hopkins might have offered to his students (Bowen, 2013).

Despite potentially large cost savings in moving teaching fully or partially online from the traditional classroom, there is a dearth of academic research that rigorously evaluates the impact of various non-traditional learning formats on student outcomes. For example, of the

1,132 studies examined in a recent U.S. Department of Education (2010) meta-analysis of online learning *at all levels* from kindergarten to graduate study, only 45 followed experimental or quasi-experimental designs, and of those 45 studies, only 5 had sample sizes greater than 400. On the basis of the 45 experimental studies, the Department of Education authors concluded that there was a modest gain in performance for students taught in online formats relative to those taught with traditional or face-to-face methods.

More recently, two research teams have also used randomized designs to evaluate fully or partially online formats in full-semester undergraduate classes. Figlio, Rush, and Yin (2013) compared students who took introductory economics online versus a traditional lecture format at a major research university. Bowen, *et al.* (2014) examine the performance of students in an introductory statistics class held on six public university campuses, contrasting the performance of students attending a traditional class with two weekly meetings with those whose class material was delivered online supplemented by one weekly class meeting. Both studies reported no overall difference in performance as measured by test grades between formats, although Figlio, Rush, Yin (2013) did find that Hispanic students and those with a grade point average below the median did less well in the online economics class.

Both of these studies make important contributions to the literature, while at the same time underscoring the challenges of undertaking randomized designs in a university setting. Participation rates in both studies were less than 25 percent, highlighting the difficulty of recruiting students when the ability to offer incentives is limited by institutional review board protocols. Such low participation rates clearly raise questions of external validity. In addition, although sample sizes in both studies were large enough to provide sufficient statistical power to detect overall differences between formats, they were not large enough for most sub-group analyses, either by baseline demographics or, in the case of Bowen, *et al.* (2014), across campuses.

Other issues beyond selective participation and small samples also affect these studies. For example, Figlio, Rush, and Yin (2013) present results showing that the mean differences in test scores between formats increased between 60 and 100 percent when adjusted for baseline covariates, suggesting a lack of balance in the characteristics of the students in each of the formats.[1] The statistics experiment conducted by Bowen, *et al.* (2014) encountered difficulty coordinating test and grading across campuses and faculty – not all campuses used a common set of questions on the final and faculty, aware they were part of an experiment, may have graded more leniently in order to reduce failure rates. Lastly, substitution bias is an ever-present threat to randomized designs in university settings. It is very difficult to limit class-specific online content only to those in a particular treatment group and students restricted to traditional lecture formats can easily access tutorials, practice problems, and videos online.[2] Online materials may not be perfect substitutes for what is covered in a specific class, but they may blur the distinction between a traditional format and either a hybrid or purely online class.

We randomly assigned 725 students into traditional and "hybrid" formats of introductory microeconomics at a large, urban, public university.[3] We examine whether students who were offered class once a week for 75-minutes over a 14-week semester performed as well as students who were offered class twice per week, each for 75-minutes. Two experienced professors (the

---

[1] Students in the "live" format scored 3 percentage points higher on the final exam (p<.05) and 2.5 percentage points higher (p<.01) on the average of all three exams than students restricted to the video-taped lectures. See Table 3 in Figlio, Rush, and Yin (2013).

[2] For example, content producers like Khan Academy (http://www.khanacdemy.org, last accessed 16 February 2014), provide excellent introductory lessons in micro and macroeconomics.

[3] Both formats could be considered "hybrid" formats because there was a significant online component in both. For ease of explication, we shall refer to the once-per-week class as the hybrid format and the twice-per-week class as the traditional format.

first two authors) taught four sections, one of each format. Students in the two formats had access to the same lecture slides, online material, and faculty-produced videos, which eliminated substitution bias as a source of attenuation since classroom time was the only difference between formats. Because research on student learning suggests that frequent assessments with immediate feedback improve performance (Pennebaker, Gosling and Ferrell 2013), we also required weekly graded quizzes for both formats. We required students in both formats to take the online quizzes both before and after lectures, using sophisticated interactive software (Aplia) to deliver and grade them. This type of software is available "off-the-shelf" from numerous publishers for large introductory undergraduate classes at less than the price of a traditional textbook. This online component of our courses should not be costly to reproduce and is easy to replicate.

We find that students in the traditional format performed better on the midterm and final exams and in their overall grade. The effects are not large, however: approximately 2.5 points on a 100-point scale. To put this result in perspective, if we divide this 2.5 point effect by the median difference in classes attended between formats, 11, then each extra class offered in the traditional format increased the final grade by 0.23 percentage points. We find little difference in attendance, as students in both formats attended the same proportion of classes, and there were no differences in withdrawal rates by format. We also find no difference in hours logged into the online software or differences in the number of videos watched by class format. We further examine the impact of attendance on performance with a non-experimental subset of our data and find that the non-experimental estimates are between 2.5 and 4.7 times greater (in absolute value) than the experimental estimates, suggesting that non-randomized designs may significantly overstate the impact of attendance on outcomes.

Our results have meaningful pedagogical and administrative implications for undergraduate education. The fundamental difference in treatment between the traditional and hybrid formats is the amount of time spent in the classroom, with students in the hybrid having only half the amount of formal class time as those in the traditional sections. Our study can therefore be viewed as a strong test of whether substantial differences in attendance matter to academic performance when online materials are also available. We provide the first experimental evidence on the effects of attendance and academic performance. When we replicate the observational literature, we get very similar (and large) estimates of the effect of attendance. Our experimental estimates of the effect of attendance are much smaller, however, and indicate that the large effects in the previous literature are likely to be due to selection on unobservable characteristics.

Given the relatively small differences in students' academic performance between formats, our study points to potential savings in terms of classroom space and faculty staffing. The software that now accompanies introductory textbooks from for-profit publishers, and administered on their servers, allows for more frequent, machine-graded assignments at little cost to universities.. These online components enhance core skill-building and enable faculty to spend classroom time on more complex material. Large lecture halls are scarce resources and small recitations are costly to staff and schedule. One faculty with many fewer teaching assistants but with online material may be able to teach twice the number of introductory students with no substantial diminution in measured learning.

I. The Experiment

Setting

The study took place at Baruch College, part of the City University of New York, and one the most ethnically diverse campuses in the country, where one hundred and sixty three countries are represented and 110 languages are spoken.[4] Baruch's Zicklin School of Business is the largest accredited collegiate school of business in the country with 12,000 undergraduates. Almost all students commute to campus and most attend full-time.

Principles of Microeconomics (ECO 1001) is a required course for all students applying to the business program at Baruch. It also fulfills a social science requirement for non-business majors. Nearly one thousand students take ECO 1001 each fall. Four sections with seats for a total of 776 students were part of our study, which accounted for 95% of the daytime non-honors seats available for the course.[5] Students could register for class on Mondays and Wednesdays in the morning or Tuesdays and Thursdays in the late afternoon. Classes were listed as taught by the first two authors of the study. Both are full-time, tenured faculty members who have taught the class for the past 6 years and both have strong teaching evaluations.[6] Registration for the fall classes began in April of 2013 and continued through August. Students currently enrolled in

---

[4] See http://www.baruch.cuny.edu/diversity/index.htm (last seen 18 February 2014) and http://www.baruch.cuny.edu/about/by_the_numbers.html (last seen 18 February 2014) for statistics about Baruch's student population.

[5] Twenty seats went unfilled in the sections of the course in this study. Just over 100 students took ECO 1001 in the evening, most of whom were part-time students. Of the remaining students who were not part of our study, one section of 25 students was reserved for honors students only, and another daytime section of 40 students was taught by an adjunct faculty member.

[6] Each professor has a rating of 4.3 based on teaching ECO 1001 on http://www.ratemyprofessors.com (last accessed February 3, 2014).

Baruch could register in April and May while transfer students from community colleges or other four-year colleges could not begin registration until June.

The Course

All sections of the class used N. Gregory Mankiw's *Principles of Microeconomics* (6th Edition) as the textbook along with Cengage Aplia software to administer and grade online quizzes. Each week students took a Sunday "pre-lecture quiz" covering material to be taught in the upcoming week, and a Saturday "post-lecture quiz" covering material that had been taught during the week. The pre-lecture quizzes were pass/fail (students who answered at least half of the questions correctly received 100% for the quiz) and were generally easier than the post-lecture quizzes; they were designed to ensure students came to lectures with some basic understanding of the material, without which the pace of the hybrid lectures in particular would have been quite challenging for most students.

Lectures by professors formed the core of ECO 1001. During lectures, the professors presented microeconomic theory and examples using Power Point slides. The same slides were used in the hybrid and traditional lectures by both professors, and were made available to all students for download, but they were covered more selectively and quickly in the hybrid format, with less time to verbally annotate the slides, work through examples, and answer student questions. There was also less time in the hybrid to go over difficult problems from the Aplia quizzes and to review practice questions for exams.[7] In addition, one of the professors recorded videos for each chapter from the text, in which he annotated answers to 10 multiple choice

[7] While several practice exams and solutions were made available to all students online, the traditional lecture format presented more opportunities to visit the practice exams during class.

questions. Each video was approximately 30 minutes long but was broken up into segments ranging from 5 to 10 minutes each, so that students could easily select only the videos for which they sought explanations. The videos were taped in a studio with no audience but the lighting and sound were professionally supervised. *A priori* we expected students in the hybrid sections to make more use of the videos than those in the traditional sections.

Because the hybrid format forced the professors to compress their lectures to fit the reduced class time, the fundamental differences between the two formats were the amount of contact that students had with their course professor and classmates, the tempo of learning required during the lectures, and the amount of class time available for questions. While other studies have tried to limit access to online material, this struck us as infeasible and a potential confounding factor for the results. All online content was available to students in both formats of the class in order to isolate the impact of classroom time on student performance. We believe the contrast between the two formats in our study is likely to be closer to the "real world" implementation of such courses. Formal online materials are likely to be available in both "traditional" and "hybrid" courses. Moreover, because classroom space and time are far more costly to provide than online materials, our treatment captures the relevant margin on which university administrators are likely to prefer one format over another.

Recruitment and Randomization

Recruitment began in May of 2013, shortly after the beginning of registration for the Fall 2013 semester. Students who had registered for one of the four class sections were sent an email inviting them to participate in the study with a link to the electronic consent form. The

Institutional Review Board of CUNY, in approving our application, allowed us to offer an incentive of five extra-credit points (out of 100) on their course average to students who participated in the study.[8] For example, if a student's course average was 90 (an A-) the student's final numerical grade was increased to 95 (an A).[9] Students who chose not to participate were allowed to do an extra credit project for the same five points.[10]

The flow of students is shown in Figure 1. Seven hundred and fifty-five students registered for the four sections of ECO 1001, of which 381 were in the Monday-Wednesday classes and 374 in the Tuesday-Thursday classes. Of the 755 registrants, 725 consented to be in the study, a 96% participation rate that represented 91 percent of all non-honors daytime students enrolled in ECO 1001. This participation rate is far greater than recent experimental studies of online learning and is likely due to the 5 point participation incentive. Thirty-two students either dropped the class before the midterm or did not take the midterm, and an additional 37 students took the midterm but afterwards either withdrew or did not take the final exam. The total post-randomization attrition rate was 9.5 percent.

We randomized students between formats within days (i.e. Monday-Wednesday or Tuesday-Thursday).[11] One section was taught in a large lecture hall that seats 274 students and

---

[8] In our IRB application we estimated that 132 students in each treatment arm were necessary for a minimum detectable effect size of 4.2 percentage points with 90 percent power. Lowering power to 80 percent, the required sample sizes fell to 98 students in each treatment arm. By offering an incentive to participate, we expected to recruit most of the 776 students that were likely to register for the 4 experimental sections. Even with a withdrawal rate of 10 percent, the research plan included large enough sample sizes to detect effects with sufficient power.

[9] The five extra credit points proved crucial to recruitment. The IRB also allowed us to offer a raffle in which 40 students picked randomly from the participants would be given priority registration for their classes in the spring of 2014. Comments from students suggested that the number of priority registrations was too few to be a significant incentive, but that the five extra-credit points for one of the 8 classes that determines admission to the business school was highly valued.

[10] Of the 26 non-participants who finished the course (2 others withdrew and 2 did not take the final), only 11 (42%) completed the extra credit project.

[11] Students that registered for a Monday-Wednesday section could not be randomized into Tuesday-Thursday sections because it would have potentially created conflicts with other classes for which they had registered.

the other section, given at the same time, was in a classroom that held 114 students.[12] Each professor taught one hybrid section and one traditional section, each in the same classroom. That is, Professor A taught a traditional section in the small classroom on Monday and Wednesday mornings and a hybrid section in the same small room on Tuesday afternoons. Similarly, Professor B taught a traditional section in the large lecture hall on Tuesday and Thursday afternoons and the hybrid section in the same room on Wednesday mornings. We can therefore control for the professor and classroom size fixed effects, but we cannot separately identify them. Moreover, the administratively imposed restriction of having different class sizes introduces a potential source of treatment heterogeneity. "Within professor" comparisons contrast students from different randomized samples and "within day" comparisons contrast performance across classroom/professor. We therefore present several sets of results: the pooled sample of all students with controls for day and classroom/professor, comparisons within classroom/professor, and third, comparisons within day but across classroom/professor and course format.

Outcomes

As with other experiments, our fundamental outcome measure is academic performance on exams and the final course grade. We administered both the midterm and final exams in class, and on both tests the same questions were used in all four sections. The midterm and final consisted of 30 and 40 multiple choice questions, respectively. The questions came both from a standardized test bank as well as being written by Professors A and B. A copy of each exam is included in the Appendix. As an overall measure of test performance, we summed the total

[12] The Baruch administration could not commit two large lecture halls during the same class period to the study given the demand from other large lecture classes.

number of correctly answered questions on the midterm and final and divided by 70, the total number of questions. We also present results with the overall course grade, in which the midterm and final exams counted for 35 and 45 percent, respectively. The remaining 20 percent of the course grade comprise online quizzes managed and graded with Cengage's Aplia software. The course grade also includes the penalty for missed classes described below, the 5 percentage-point bonus for participation, as well as curves for each exam.[13] In the results that we present below, we scale all test scores and the course grade so that they range from 0 to 100. We prefer the midterm+final measure of academic performance because unlike the course grade it is does not conflate non-cognitive (attendance) and cognitive (exams and online quizzes) outcomes.[14]

The primary purpose of the Aplia quizzes was to encourage students to keep up with the material and improve their preparation for the lecture. They were not supervised (i.e. we cannot determine whether students did their own work or worked with other students) and were intended as low-stakes assessments. Except for the week in which the midterm was given, students had a pre-lecture quiz that was graded on a pass-fail basis with only one attempt at the correct answer, and a post-lecture quiz that was graded on the percent correct.[15] Students were permitted three attempts at the correct answer on the post-lecture quiz. In calculating the contribution of the Aplia quizzes to the final grade calculation, each quiz was weighted proportionately to its total possible points (on average, the post-lecture quizzes were worth about three times as many

[13] Each exam was curved so that the median curved exam score was 80%. As a result of this curve, 2 points (out of 30) were added to each midterm score and 6 points (out of 40) were added to each final exam score in the calculation of course grades.

[14] Attendance is potentially endogenous and students could have worked with other students on their Aplia quizzes even for the questions that were algorithmic. Thus, the overall grade is a less-controlled measure of performance than the midterm and final exams.

[15] A student who answered at least 50% of the questions correctly on a pre-lecture quiz earned full points, while a student who answered less than 50% correctly received no adjustment. Thus 8 out of 15 correct was bumped up to 15/15, while 7 out of 15 was recorded as 7/15.

points as the pre-lecture quizzes), and for each student we dropped the pre-lecture quiz and post-lecture quiz that most adversely affected his or her grade.

In addition to students' cognitive performance, we also examine whether the different formats elicited different amounts of non-cognitive effort. First, we took attendance at every lecture. Students were required to swipe their student identification cards in a card reader within the first 15 minutes of class. The readers were linked to the registrar's database and the presence (or absence) of each student was verified and stored on a college server. Excluding the midterm and the first week of class, which did not count towards attendance requirements, students were allowed to miss 6 out of 25 lectures in the traditional format and three out of 12 in the hybrid format without penalty, i.e. approximately 25 percent of the lectures. In the traditional classes, students lost one percentage point from their final grade for any late or missed classes beyond the six permitted absences, and in the hybrid classes students lost two percentage points for any late or missed classes beyond the three permitted absences. The policy provided an incentive for students to swipe their ID cards, but it also created potentially meaningful variation in attendance within format.[16]

Second, we analyze withdrawal rates. We count as withdrawals students who enrolled in the class and consented to be in the study, but failed to finish.[17] We also measured withdrawals between the midterm to the final. Withdrawal rates are an important indicator of students' ability to manage a hybrid format, but they also allow us to gauge the potential for attrition bias.

[16] Recitation sections, led by a graduate student, were held in conjunction with both large lectures. Each of the four recitations had a class size of almost 70 students. Attendance was voluntary, however, and extremely low. On average, students attended 1.1 recitations out of a possible 13 and the median and modal number of recitations attended was zero. There was no recitation available to students in the smaller classroom. Given the low participation rate, however, the presence of recitations should have little impact on the results.

[17] As noted, ECO 1001 is one of the eight classes that determine entrance to the Zicklin School of Business. Students can withdraw or not even show up for the final and accept a grade of F because they can retake the class and replace the F on their transcript. We treated official withdrawals and "no-shows" as the same.

Third, for online content, we measured how many course videos the students watched. Because the videos were located all on one page in Blackboard, we can only measure how many videos were watched, but not which videos.[18] *A priori*, we expected students in the hybrid sections to watch more videos. Lastly, In addition to quiz results, we measured the number of hours students spent logged on to Aplia.

II. Data

We combined several sources of data. All baseline characteristics were obtained from Baruch College's Office of Institutional Research and Program Assessment. These data included age, race/ethnicity, language spoken at home, major (if declared), grade point average (GPA), SAT scores, and cumulative credits. Some students have a GPA at Baruch, while transfer students have only GPA from their former college. Former transfer students have both GPAs. In the regression analysis, that follows, we include both GPAs and indicator variables for missing one or both of those GPAs.[19] We also do not have SAT scores for all students because not all transfer students were required to take the SATs. We also administered two short surveys to students in the first and last week of classes. We solicited their attitudes toward hybrid courses and whether they worked for compensation during the semester The Aplia server routinely collected data on student use and data on the number of videos watched were collected from the Baruch Blackboard servers.

[18] The decision to locate all the videos on one page was made by the Baruch IT department.

[19] We have Baruch GPAs for about 78% of our sample, and Baruch or transfer GPAs for about 93% of our sample. We have both Baruch and transfer GPAs for about 20% of our sample. Baruch accepts many transfer students, particularly from other CUNY schools; only about 58% of our sample is "native" Baruch students.

III. Results

Summary statistics and balance

We present the baseline characteristics of students by format in the pooled sample in Table 1. Characteristics of students at the start of the experiment are shown in the left panel and characteristics at the end of the semester are shown in the right panel. Overall, balance is superb, with no statistically significant differences between traditional and hybrid formats on any of the sample characteristics in the beginning sample and only one statistically significant difference (age) between the formats among students who took the final exam. For both samples we estimated a logit with hybrid (1=hybrid, 0=traditional) as the dependent variable and all of the characteristics (as well as indicators for missing values) as the dependent variables. The *p*-value for the overall χ^2 statistic from these regressions is 0.626 for the initial registrants and 0.157 in for the students who took the final exam. We also show the distribution of characteristics for the Monday-Wednesday and Tuesday-Thursday sections in Appendix Table 1 and these show similarly excellent balance.

Table 2 shows the baseline characteristics within professor/classroom. Estimating similar logit models as in Table 1 yields *p*-values that are larger than .05 for both the beginning and ending samples for Professor A and also in the beginning sample for Professor B, while in the ending sample for Professor B the differences are jointly significant at the 3.7% level. For both Professors, we do find some differences in the proportion of Asian students, who were more likely to register for Tuesday-Thursday sessions than Monday-Wednesday sessions. There are also some statistically significant differences for Professor A in prior academic performance experience. Recall that we could not randomize within professor/classroom because we could not randomize across the Monday-Wednesday and Tuesday-Thursday schedules, as this would have caused conflicts with students' other scheduled classes, and student preferences for taking classes on different days or at a different time of day may lead to some small differences between the hybrid and traditional groups for each professor. Overall, however, the balance within professor is excellent.

Performance On Tests and Quizzes: Pooled Sample

We show differences in student performance on the midterm, final, the combination of both, Aplia quizzes, and the final course grade in Table 3. As noted above, we scaled all results to range from 0 to 100 to facilitate comparisons across the various performance metrics. For each outcome we show unadjusted (in odd-numbered columns) and adjusted (in even-numbered columns) mean percentage point differences. In all regressions in Table 3 we include an indicator for the Monday-Wednesday classes because the probability of being placed into the hybrid was different in the two randomization pools in the experiment. In practice, however, this variable is never statistically different from zero. Across all performance measures, we find that students in the hybrid format did less well than students in the traditional format, and that these differences, except for Aplia scores, are statistically significantly different from zero. Adjusting for baseline covariates narrows the estimated mean differences between formats by a few tenths of one percentage point relative to the unadjusted differences. The covariates also tighten the standard errors and greatly improved the explanatory power of the model. In general, adding covariates increases the R^2 from around 1 percent to 30 percent or more. The consistency of the unadjusted and adjusted results speaks to the balance in the pre-treatment covariates.

Our preferred measure is the combined midterm and final score (columns 7 and 8). We find that on average, students in the hybrid format scored around 2.5 percentage points less than students in the traditional format, adjusted for covariates.[20] This 2.5 percentage point difference represents one fewer correct answer on a test of 40 questions, a relatively modest effect. In terms of standard deviations, this effect is about .2 standard deviations of the mean score of students in the traditional sections. The lower bound of the 95 confidence interval from the estimated effect in column 8 is -4.2, approximately one half of a letter grade, which is more substantial. The results were nearly identical for the overall course grade (columns 11 and 12).

Differences in test scores by format were larger for the midterm (columns 1 and 2) than the final (columns 5 and 6). We present results for the midterm for those students who completed the class in columns 3 and 4. The results are nearly identical to those in columns 1 and 2, suggesting that there is not selective attrition between the formats. This is confirmed in the results in Table 7 below, where we find no differences across format in the overall withdrawal rate or withdrawal after the midterm.

To examine visually the effects of being in different formats, in Figure 2 we show kernel density estimates of all of outcomes in Table 3 for the hybrid and traditional formats. The red lines indicate the densities for the distribution of outcomes in the hybrid sections while the blue lines indicate the distribution of outcomes in the traditional sections. The shaded area below each plot shows the difference in densities between traditional and hybrid formats. The plots reveal a roughly symmetrical distribution of exam scores and the final grade, with the hybrid

[20] The full output for the adjusted estimates is presented in Appendix Table 2. Students' GPAs and math SAT scores are, unsurprisingly, the primary predictors of class performance.

distribution shifted slightly left to that of the traditional distribution. The exception is the scores on the Aplia quizzes, which are nearly identical across formats, but are clearly skewed left, reflecting that students were allowed three attempts to answer post-lecture quizzes correctly but some students didn't submit several assignments. We performed two-sample Kolmogorov-Smirnoff tests on the difference between the densities in each of the panels of Figure 2. We rejected the null hypothesis of equal densities only for the midterm, where the test had a *p*-value of 0.078. We also performed two-sample Kolmogorov-Smirnoff tests on the difference in the raw (unsmoothed) distribution between the hybrid and traditional sections for all of the outcomes in Table 3, and rejected the null hypothesis of equal distribution for the midterm (p=.04), midterm plus final (p=.02), and the course grade (p=.096).

Performance On Tests and Quizzes Within Professor/Classroom

As discussed earlier, for administrative reasons we were unable to procure classrooms of equal size. Each professor taught in either a small classroom with a capacity of 114 students (Professor A) or a large classroom with a capacity of 274 students (Professor B). Although we control for professor/classroom fixed effects in Table 3, we cannot separately control for the professor effect and the classroom effect, and it is possible that there is treatment heterogeneity across classroom sizes that we would not capture in those results. To examine whether this is an issue, we present estimates of the treatment effects separately for each professor/classroom in Table 4. The top panel shows the results for Professor A (in the smaller lecture hall) while the bottom panel shows the results for Professor B (in the larger lecture hall). The outcomes are the same as in Table 3 and columns present unadjusted and adjusted treatment effects as in Table 3.

Overall, the results are quite consistent with those from the pooled sample shown in Table 3. Students in the hybrid taken in the large lecture hall (Professor B) scored approximately 3 percentage points lower on the combined midterm and final than students in the traditional class (lower panel, columns 5 and 6). Differences by format are somewhat less in the smaller classroom but are not as precisely estimated, reflecting the smaller sample size (upper panel, columns 5 and 6). The estimated differences are also more sensitive to the inclusion of covariates than those in the pooled sample in Table 3. Recall that we only randomized within days. The within professor/classroom estimates therefore compare students from two different randomized samples. Although the balance of baseline characteristics by format appears reasonable, there are greater differences in some characteristics by format, as we showed in Table 2. We view these results as being quite comparable to those from the pooled sample, however, while eliminating an important source of heterogeneity.

Performance on Tests and Quizzes Within Day

To illustrate the importance of professor/classroom heterogeneity, we show estimates of the hybrid effect comparing within days in Table 5. The top panel (Monday-Wednesday) compares outcomes of students in which the hybrid class was delivered in the large lecture hall and the traditional class in the smaller room. In the bottom panel (Tuesday-Thursday) the opposite occurred: students in the hybrid format were in the smaller classroom and those in traditional format had class in the large lecture hall. The differences are striking. Students in the hybrid format scored over 5 percentage points less on the combined midterm and final (top panel, columns 6 and 7) than those in the traditional class when the hybrid was delivered in the large lecture hall, but there was no difference between formats when the hybrid class was given in the smaller classroom (lower panel, columns 6 and 7). These differences are not likely due to imbalance between students in the two formats because randomization occurred within day (see Appendix Table 1). The results are at least suggestive that smaller class sizes may play an important role in learning. Students in smaller classes meeting less frequently seem to perform about as well as students in larger classes that meets twice as often.

Performance On Tests: Interaction Effects

Our previous results may mask differences in performance for students with different characteristics. In Table 6 we show the interaction effects of various student characteristics with the hybrid indicator using the combined midterm and final score as the outcome.[21] For each model we include main effects for the hybrid and the characteristic of interest along with the Monday-Wednesday indicator. For models with covariates, we include the full set of covariates as employed in Table 3. Previous findings by Figlio, Rush and Yin (2013) suggest that that the performance of students with a higher baseline GPA may be less affected by the lecture format than weaker students who may need more interactive classroom time. In columns 1 and 2 we present unadjusted and adjusted effects for students in the upper half of the baseline GPA distribution.[22] Unlike Figlio, Rush, and Yin (2013), we find no evidence that low-GPA students perform worse in the hybrid format.

[21] Results for the other test-based outcomes are similar and are available from the authors by request.

[22] Recall that we do not observe a Baruch GPA for new transfer students or for first year students. To create a single baseline GPA index, we regressed Baruch GPA on a quadratic in transfer GPA, a quadratic in age, the number of cumulative credits, an indicator for female, and an indicator for being an underclassman for the 158 students for whom we observe both (transfer students who have been at Baruch at least one semester). We use this predicted

We do not find any differences in being in the hybrid by sex (columns 3 and 4) or race (columns 5 and 6). Given that students in both formats have access to online materials, we might expect that non-native English speakers would find it more difficult to keep up with the faster learning tempo in the hybrid format. But here we also find no difference in effects of being in the hybrid format (columns 7 and 8).

Students who work may prefer the flexibility of having fewer class hours to attend. In columns 9 and 10 we find relatively large, but imprecisely estimated, negative effects of being in the hybrid for working students. This suggests that although working students may find the hybrid more convenient, fewer class hours also translates into fewer hours spent learning overall, which manifests itself in a poorer performance. In our data, students who worked spent somewhat less time watching videos and working on Aplia as students do did not work. Students who worked more than 30 hours per week were also less likely to attend class.[23]

Attendance, Online Usage, Attrition, and Other Classes

In addition to test scores, we also examine the effect of being in the hybrid format on a variety of non-cognitive outcomes related to effort. In Table 7 we present the impact of the hybrid format on attendance, the number of videos watched, time spent online using Aplia, the probability of withdrawing from the class at any time, and the probability of withdrawing from the class after the midterm. Columns 1 and 2 show that there is no difference between the

Baruch GPA for students with only a transfer GPA. Our predicted Baruch GPA has a correlation of .504 with the actual Baruch GPA within the sample of 158 students who have both. Non-transfer first year students will have neither a transfer GPA or a Baruch GPA, and for these observations (*n*=34) we include a dummy variable for missing GPA.

[23] We also estimated models similar to those in Table 7 below with attendance and online usage as the outcomes, but with the hybrid indicator interacted with working. Although rarely statistically significant the estimated coefficients on the interaction terms were usually negative.

formats in the average proportion of classes attended. We do find, however, that students in the smaller classroom taught by Professor A were somewhat more likely to attend and that students that had the morning Monday-Wednesday lectures were 2.2 percentage points less likely to attend than those with in the late afternoon Tuesday-Thursday lectures. We should note, however, that 17 percent of students in the hybrid class were penalized for excessive absences, relative to 9 percent in the traditional format.

In column 3 we show that students in the hybrid format watched 1.8 more videos relative to a mean of 8.5 videos than students in the traditional format. It is noteworthy that when we add the professor/classroom fixed effect (and other covariates) in column 7, we find that students whose professor was in the videos watch 8.6 more videos than those whose professor was not in the videos. Students appear drawn to videos in which *their* professor appears rather than an unknown "talking head." The finding argues for personalizing online material as much as possible. We find no differences in the number of hours students spent on Aplia (columns 5 and 6), although students spent a substantial amount of time on Aplia. The mean was 44 hours or about 3.1 hours per week over 14 weeks. Although the result is not statistically significant, there appears to be some evidence that students in Professor A's classes substituted time watching videos for time on Aplia. Overall, student effort as measured by attendance, videos, and online quizzes was largely the same by format. Importantly, students in the hybrid format did not appear to substitute more use of the measurable online material for reduced time they spent in the classroom. While it is possible, of course, that students in the hybrid format spent more time studying the textbook or with other online materials that we do not measure, we suspect that reducing time in class leads to an decrease in the total amount of time that students were engaged with ECO 1001 relative to those in the traditional format.

The lack of differences in attendance and intensity of online usage by format indicates that students in the hybrid class had, on average, a minimum of 13.8 more hours during the semester to apply to other material related ECO 1001 or to their other courses.[24] As a check we tested for variation in student grades in the other classes taken in the same semester with ECO 1001 by format but found no differences.[25]

It is possible that fewer contact hours with their professor might lead students in the hybrid section to withdraw from the course differentially. In columns 7 and 8 we present results indicating that students did not withdraw more at any time from the class in the hybrid sections and in columns 9 and 10 we find the same result for withdrawal after the midterm. These findings are important, because they indicate that attrition bias is unlikely to affect our results.

Student Surveys: Preference for Hybrid or Traditional

We surveyed students in the first and last week of classes about their preferences for one format or the other. In the first week of class, we asked students to rate the statement, “I would have chosen the hybrid over the traditional format if I had had the choice,” on a 4-point scale (“Strongly Agree,” “Agree,” “Disagree,” and “Strongly Disagree”). The students exhibited a strong *a priori* preference for the hybrid, but it varied by their random assignment: 78 percent of those randomly assigned to the hybrid format agreed or strongly agreed, but only 55 percent in the traditional format did. When we asked students at the end of the semester (but prior to the final exam or knowing their final grade) if they would chose the same format for their next

[24] The difference in the median number of classes attended between the two formats was 11, and each class period was 75 minutes. This figure does not include time getting to and from class.
[25] These results are available from the authors by request.

economics class, the results shifted in favor of the traditional format: sixty-five percent of the students in the traditional class but only 54 percent in the hybrid agreed or strongly agreed. Thus, the preference for the traditional format increased by 20 percentage points from the beginning of the semester amongst those in the traditional format, while the preference for the hybrid format decreased by 24 percentage points among those in the hybrid format. Despite this change in preferences, 67 percent of students in the traditional format and 62 percent in the hybrid format agreed or strongly agreed that having class twice a week helped their grade, but 62 percent students in the hybrid format disagreed with the statement that the hybrid format hurt their grade. Somewhat surprisingly, we found no differences in responses when we stratified the data by the students' baseline GPA. We interpret the survey results to mean that students found the hybrid format appealing before having experienced it, but found it challenging during the semester. A substantial proportion would not opt for the hybrid format for their next economics class.

IV. Comparison with Observational Estimates of the Effect of Attendance

Our fundamental experimental manipulation was to randomly assign the number of classes that students attend. The experimental treatment limited hybrid students to at most 13 classes, inducing a difference in the median number of classes attended to 11, i.e. traditional format students attended nearly twice as many classes as those in the hybrid format.[26] Because all of the other inputs (textbook, lecture slides, online content, office hours, etc.) were identical between the two formats, this provides a strong test of the effects of attendance on academic

[26] We permitted any student in the hybrid sections to attend traditional classes if they asked. Five students chose to do so. For these students the percent of classes attended could exceed 100 percent.

performance and is, to our knowledge, the first such experimental evidence. Although the induced change in attendance may seem quite large, numerous non-experimental studies have used differences in attendance of 50 to 75 percent to quantify effects of attendance on student performance (Romer, 1993; Devadoss and Foltz, 1996; Kirby and McElroy, 2003; Cohn and Johnson, 2003). In these studies, the researchers extrapolated the marginal impact of class attendance on student performance, adjusted for student characteristics.

To contrast our experimental estimates of the effects of attendance on performance with those from non-experimental studies, in the old-numbered columns of Table 8 we present results where we regress measures of student performance (final exam, midterm plus final, and course grade) on the number of classes attended *using only students in the traditional format*. These estimates are of course vulnerable to the same omitted variable problems as the previous observational studies. Although we had a mandatory attendance policy, there was no penalty for missing up to six lectures in the traditional format, and there is still substantial variation in attendance. Among those students in the traditional format who took the final exam, the median number of classes attended was 22, the minimum was 2, and the standard deviation was 3.1. We include the same set of control variables as in Table 3, except that instead of separately entering Baruch GPA and Transfer GPA, we include as a summary measure the Predicted Baruch GPA measure used in Table 6.

The results of regressing the final exam score on classes attended for the traditional format students are shown in column 1 of Table 8. We find that an additional class attended is associated with 0.54 percentage point gain on the final exam (column 1). As shown in the bottom row of the table, using this result, a student who missed 11 classes in the traditional format would be expected to score 6.4 percentage points less (0.58 x 11) on the final exam, or approximately two-thirds of a full grade. Because 11 classes is the median difference in classes attended between the traditional format and hybrid format, this result allows us to compare this impact with our experimental estimates. Students who increased their attendance by 50 percent of 25 class meetings would be expected to increase their final exam grade by 7.25 percentage points ($12.5 \times .58 = 7.25$).

This estimate is very close to results in the observational literature on class attendance. Romer (1993) found that an increase in attendance from 25 to 100 percent would increase performance in an introductory economics class by a full grade. Devadoss and Foltz (1996) also reported that a 50 percent increase in attendance would boost a student's performance by a full grade in various agricultural economics classes. Kirby and McElroy (2003) estimated that students who increased attendance at tutorials from zero to the mean of 62 percent would improve their grade by 13 percentage points while Cohen and Johnson (2003) report that students missing 50 percent of classes reduced students' scores by 4.3 percentage points. More recently, Dobkin, Gil and Marion (2010) used a clever regression discontinuity design to compare the performance of students who scored just below the median on the midterm, and who were required to attend subsequent classes, to students who scored just above the median on the midterm for whom attendance remained voluntary. Assuming effects are linear, they found that mandatory attendance after the midterm increased the final test score by 0.17 standard deviations for every 10 percentage point increase in attendance. To make our results comparable to Dobkin, Gil and Marion (2010), note that the standard deviation on the final exam in the traditional format was 5.9 and that a 10 percent increase in classes would be 2.5 classes. Therefore, increasing attendance by 10 percent would lead to an increase in the score on the final of 1.35 percentage points, or 0.23 standard deviations. Overall our non-experimental estimate of the association between attendance and performance from our non-randomized analysis is consistent with the previous observational literature.[27] We find a somewhat smaller effect for the combined final and midterm score (column 3) and a larger effect for the course grade (column 5).

We contrast our non-experimental estimates with the experimental estimates for the final exam in the even-numbered columns of Table 8. Comparing the effect of an 11 class increase in attendance in the last row, the non-experimental estimates of the effect of attendance on performance are from 2.5 times (for the combined midterm and final) to 4.7 times (for the course grade) greater than our estimate based on the randomized design. Taken at face value, these comparisons suggest that the non-experimental estimates are biased upwards, even after controlling for GPA, SAT scores, and cumulative credits. Students who choose not to attend class may be less motivated, diligent, or organized than students that always attend even after adjustment for these key observable determinants of performance.

This interpretation of our results comes with three caveats. First, the non-experimental extrapolations (including ours) all assume a linear effect of attendance on performance. The effect may be concave, however, with smaller marginal increases in performance as more classes are attended. Second, our required weekly pre-quizzes and post-quizzes may have reduced the gains from class attendance relative to studies without such course requirements, since our students had an incentive to interact with the material regularly even in the event of missed classes. Third, we assume that attending one less class each week in the hybrid format is the equivalent to missing one lecture in a course structured to present material over two lectures. This also may not hold completely. To give a concrete example, consider a chapter on perfect

[27] The comparison comes with caveats. The online material for introductory economics posted for the class but also available from the Internet more generally may lessen the importance of class attendance as compared to 10 to 20 years ago.

competition. In the traditional class, the first lecture of the week may cover short-run profit maximization and derivation of the short-run supply curve. In the second lecture of the week, students are exposed to the dynamics of competition and long-run equilibrium. In the hybrid format we attempted to touch on all four topics in one lecture.

V. Conclusion

We found that students in a traditional lecture format of introductory microeconomics, with twice as much face-to-face instruction, did modestly better than students in a hybrid version of the same class.   The difference was equivalent to one question in a 40-question exam. We found no differential effects by GPA or for those who are native English speakers, but suggestive evidence that students in the hybrid format who worked did less well than their working counterparts in the traditional format.

We have improved on the existing literature in several important dimensions. First, we had a 96 percent participation rate and an attrition rate of 10 percent that did not vary across experimental treatments. Second, each of the two participating faculty taught one of each format, which allowed us to control for faculty fixed effects, a potential source of heterogeneity. Third, all students had access to the same lecture notes and online materials.   This eliminated an artificial and arguably unenforceable restriction of access to online materials for students in the traditional class. Lastly, our sample was large, with 725 student at the beginning of the experiment and 656 at completion.   Given the apparent success of the randomization, we have a strong claim to internal validity.

Our results are similar to those of Figlio, Rush and Yin (2013) who reported that students in the live lecture of introductory economics scored a statistically significant 2.5 percentage points higher on the average of three exams relative to those in the online section, adjusted for covariates. Our point estimates are also within the 95 percent confidence intervals of the difference between scores obtained by students in the hybrid and traditional statistics classes studied by Bowen et al. (2013).

Our findings pertain to large urban public universities in which the vast majority of students commute. Fifty percent of participants in the study were transfer students to Baruch, 21 percent from community colleges within the City University of New York system, a population is similar to that in Bowen et al. (2013).[28] Given this population, our results are also relevant to recent studies of online instruction at community colleges, because the vast majority of students at Baruch also commute (Jaggars and Xu, 2011; Xu and Jaggars, 2013). In Washington State, Xu and Jaggars (2013) reported that community college students scored a full grade lower in courses delivered completely online relative to their counterparts who took courses in a traditional face-to-face environment. Differences in performance by format were much smaller in our study, which is further evidence that purely online courses may be more challenging for students that commute and work.

The hybrid format was not costly to produce. The software available from publishers in the introductory undergraduate courses is constantly improving, greatly facilitating the move to a "flipped classroom." Faculty can assign frequent homework and quizzes as well as provide students with additional practice problems, videos and whiteboard supplements. Much of the skill building of basic concepts can be done outside of the classroom, preserving class time for

[28] Indeed Baruch College was one of the six sites in the study by Bowen et al. (2013).

clarification of more complex concepts. The potential gains in faculty productivity as measured by faculty compensation per student, as well as better use of limited classroom space, are obvious sources of savings for large introductory classes traditionally delivered twice a week in a limited number of lecture halls with multiple small-group recitations. Bowen et al. (2013) estimate savings from a hybrid class based on labor costs alone to be between 36 and 57 percent. Clearly more work on cost and savings from hybrid formats is needed. Our study has demonstrated that face-to-face instruction in large, introductory economics classes can be greatly reduced if readily available technology is effectively applied, with little impact on student performance. We are confident that our findings are relevant for introductory classes in the natural sciences, mathematics, statistics, and other social sciences.

References

Bowen, William G. 2013. *Higher Education in the Digital Age* (Princeton, NJ: Princeton University Press).

Bowen, William G., Matthew M. Chingos, Kelly A. Lack, Thomas I. Nygren. 2014. "Interactive Learning Online at Public Universities: Evidence from a Six-Campus Randomized Trial," *Journal of Public Policy Analysis and Management* 33(1): 94-111.

Figlio, David, Mark Rush, and Lu Yin. 2013. "Is it Live or Is It Internet? Experimental Estimates of the Effects of Online Instruction on Student Learning," *Journal of Labor Economics* 31(4): 763-784.

Cohn, Elchanan. and Johnson Eric. 2006. "Class Attendance and Performance in Principles of Economics,"*Education Economics* 14(2): 211-233.

Collins, Ellaine D. 2013. "SJSU Plus Augmented Online Learning Environment Pilot Project Report." The Research & Planning Group for California Community Colleges, 2013. http://www.sjsu.edu/chemistry/People/Faculty/Collins_Research_Page/AOLE%20Report%20-September%2010%202013%20final.pdf (last accessed 16 February 2014).

Devadoss, Stephen and John Foltz. 1996. "Evaluation of factors influencing student class attendance and performance," *American Journal of Agriculture Economics* 78(3): 499-507.

Dobkin, Carlos, Gil, Ricard, and Justin Marion. 2010. "Skipping Class in College and Exam Performance: Evidence from a Regression Discontinuity Classroom Experiment," *Economics of Education Review* 29(4): 566-575.

Eurich, Alvin C. 1958. "A Foundation Looks at College Teaching by Television," *Journal of Educational Sociology* 31 (9):329-336.

Ho, Andrew Dean, Justin Reich, Sergiy O Nesterko, Daniel Thomas Seaton, Tommy Mullaney, Jim Waldo and Iasaac Chung. 2014. "HarvardX and MITx: The First Year of Open Online Courses, Fall 2012-Summer 2013. SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2381263 (last accessed 27 February 2014).

Jaggars, Shanna Smith and Di Xu. 2011. "Online and Hybrid Course Enrollment and Performance in Washington State Community and Technical Colleges," Community

College Research Center Working Paper Number 31, Teachers College, Columbia University, March.

Kirby, Ann and Brendan McElroy. 2003. “Does Attendance Affect Grade? An Analysis of First Year Economics Students in Ireland,” *Economic and Social Review* 34(3): 311–326.

Lewin, Tamar. 2013. “After Setbacks Online Courses Are Rethought.” *New York Times*, December 10. http://www.nytimes.com/2013/12/11/us/after-setbacks-online-courses-are-rethought.html (last accessed 16 February 2014).

Macmitchell, Leslie T 1955. “Are Institutions Planning Ahead?” *The Journal of Higher Education* 26 (9): 463-469+504.

Mankiw, N. Gregory. 2012. *Principles of Microeconomics 6th* (Mason, Ohio: South-Western).

Pennebaker, James W., Goslings, Samuel D. and Jason D. Ferrell. 2013. “Daily Online Testing in Large Classes: Boosting College Performance while Reducing Achievement Gaps,” PLoS ONE 8(11): e79774. doi:10.1371/journal.pone.0079774

Romer, David. 1993. “Do Student Go to Class? Should They?” *Journal of Economic Perspectives* 7(3): 167-174.

Rudolf, Frederick. 1956. *Mark Hopkins and the Log: Williams College 1836-1872* (New Haven, CT: Yale University Press).

U.S. Department of Education. 2010. *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Anlysis and Review of Online Learning Studies*, Washington, D.C. http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf (last accessed 16 February 2014).

Xu, Di, and Shanna Smith Jaggars. 2011. “The Effectiveness of Distance Education Across Virginia's Community Colleges: Evidence From Introductory College-Level Math and English Courses,” *Educational Evaluation and Policy Analysis* 33: 360-377

Xu, Di, and Shanna Smith Jaggars. 2013. “The Impact of Online Learning on Students’ Course Outcomes: Evidence from a Large Community and Technical College System,” *Economics of Education Review* 37: 46-57

Figure 1
Flowchart of Student Intake and Random Assignment

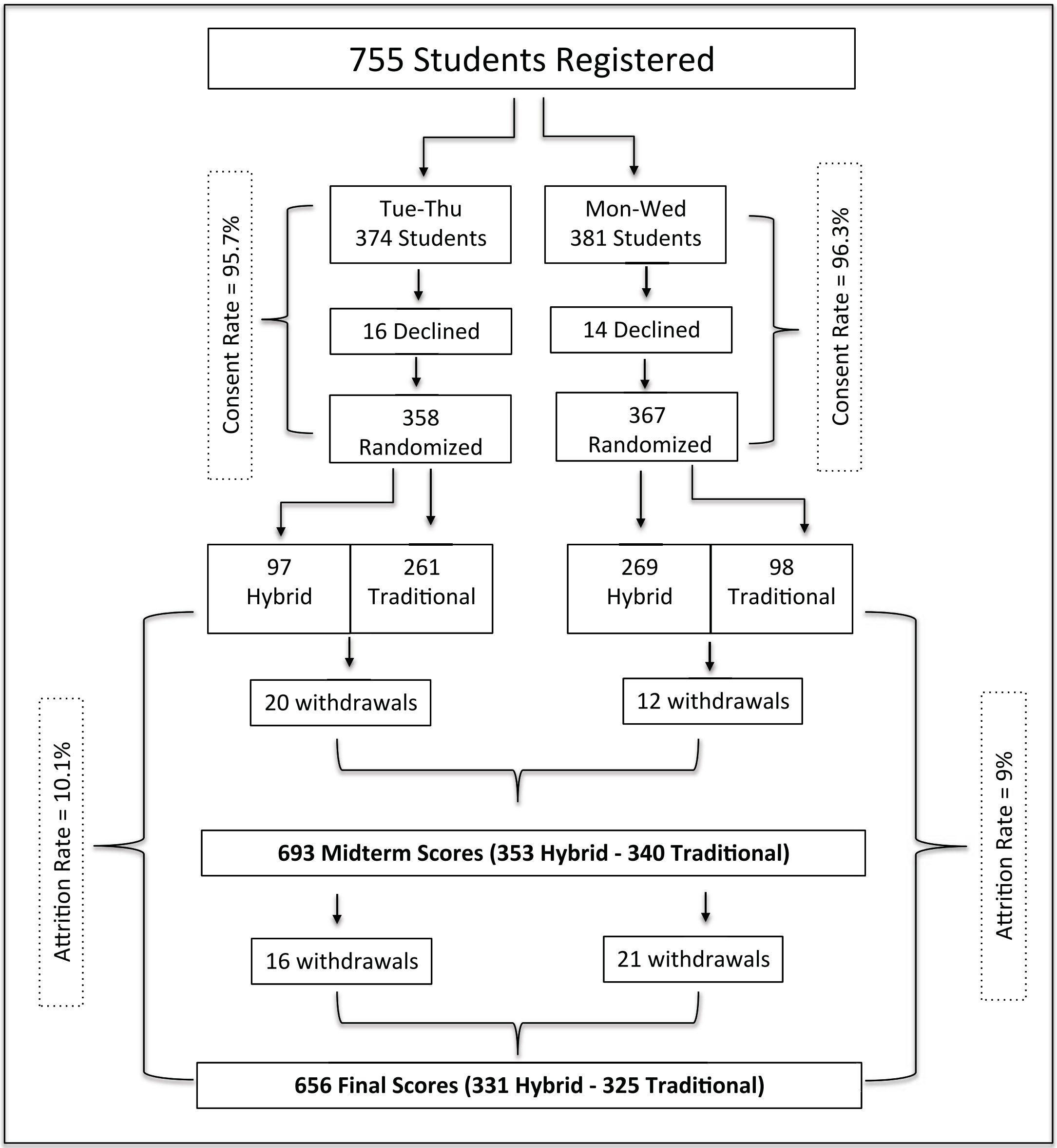


Figure 2
Kernel Density Estimates of Student Performance

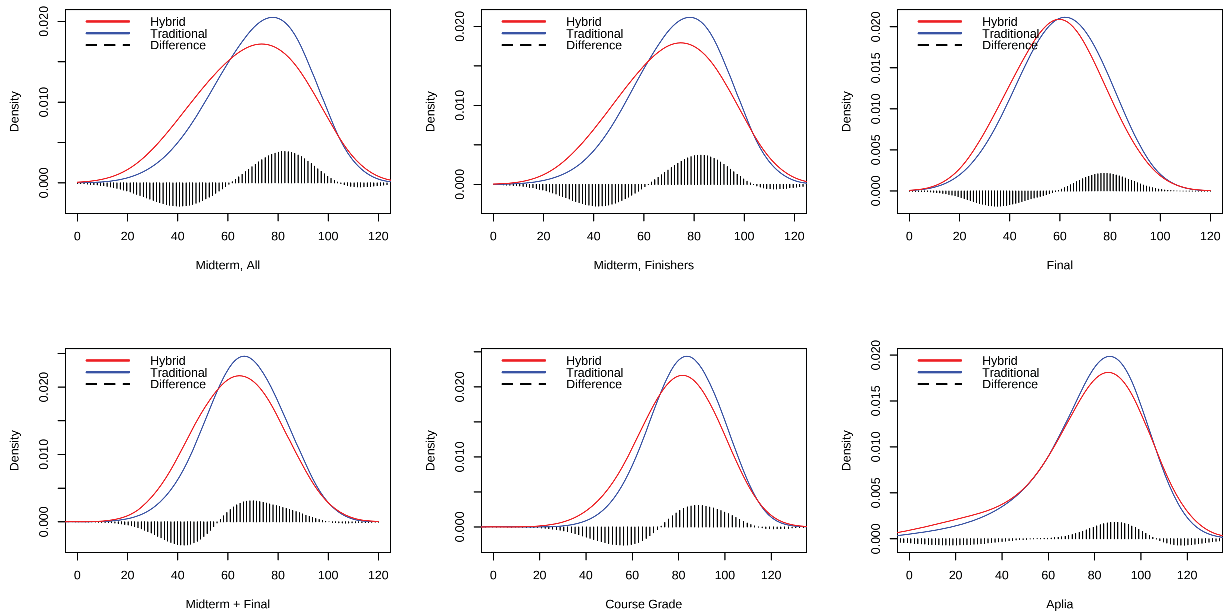


Table 1
Baseline Characteristics of Participants at the Beginning and End of the Semester

	Beginning Sample				Ending Sample			
Covariate	**Tradi-tional**	**Hybrid**	**Hybrid-Trad.**	***N***	**Tradi-tional**	**Hybrid**	**Hybrid-Trad.**	***N***
Prior Academic Performance								
Baruch GPA	3.00	3.01	0.01	568	3.01	3.06	0.05	518
Transfer GPA	3.31	3.26	-0.05	265	3.34	3.28	-0.06	230
SAT Verbal	541.56	533.31	-8.25	556	544.71	537.12	-7.60	511
SAT Math	601.90	596.17	-5.73	556	607.42	600.94	-6.48	511
Prior Academic Experience								
Cumulative Credits	45.93	44.98	-0.95	725	45.24	43.96	-1.28	656
Underclass	0.73	0.77	0.04	725	0.74	0.79	0.05	656
Attends Part Time	0.08	0.07	-0.00	725	0.08	0.07	-0.02	656
Demographic Characteristics								
Age	21.22	20.93	-0.30	725	21.23	20.70	-0.53 **	656
Female	0.45	0.48	0.02	725	0.44	0.46	0.02	656
Asian	0.44	0.43	-0.02	606	0.46	0.44	-0.03	546
Black, Hispanic, Other	0.31	0.28	-0.03	606	0.29	0.26	-0.03	546
Native English Speaker	0.54	0.53	-0.02	621	0.53	0.53	0.00	561
p-value, joint χ^2-test	0.626				0.157			

Note: Statistical significance tested using two-sample *t*-tests assuming equal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Hybrid on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample size for left panel is 725, sample size for right panel is 656.

Table 2
Baseline Characteristics of Participants at the Beginning and End of the Semester by Professor / Classroom Size

	Beginning Sample				Ending Sample			
Covariate	**Traditional**	**Hybrid**	**Hybrid-Trad.**	***N***	**Traditional**	**Hybrid**	**Hybrid-Trad.**	***N***
			Professor A / Small Classroom					
Prior Academic Performance								
Baruch GPA	3.06	2.89	-0.18 *	143	3.08	2.95	-0.13	131
Transfer GPA	3.37	3.32	-0.05	71	3.42	3.31	-0.11 *	65
SAT Verbal	543.52	520.67	-22.85	146	545.61	520.14	-25.47	138
SAT Math	609.01	594.53	-14.48	146	614.39	596.11	-18.28	138
Prior Academic Experience								
Cumulative Credits	48.80	42.58	-6.22 *	195	47.94	41.87	-6.08 *	181
Underclass	0.67	0.81	0.14 **	195	0.70	0.82	0.12 *	181
Part time	0.11	0.05	-0.06	195	0.12	0.04	-0.07 *	181
Demographic Characteristics								
Age	21.26	20.89	-0.37	195	21.27	20.67	-0.60 *	181
Female	0.48	0.48	0.00	195	0.48	0.47	-0.01	181
Asian	0.36	0.58	0.22 ***	160	0.39	0.58	0.19 **	148
Black, Hispanic, Other	0.30	0.18	-0.12 *	160	0.26	0.17	-0.09	148
Native English Speaker	0.54	0.51	-0.03	171	0.52	0.50	-0.02	161
p-value, joint χ^2-test		0.126				0.221		
			Professor B / Large Classroom					
Prior Academic Performance								
Baruch GPA	2.98	3.05	0.08	425	2.98	3.10	0.11 *	443
Transfer GPA	3.29	3.23	-0.06	194	3.31	3.26	-0.05	157
SAT Verbal	540.86	537.78	-3.08	410	544.38	543.38	-1.00	373
SAT Math	599.34	596.75	-2.60	410	604.83	602.72	-2.11	373
Prior Academic Experience								
Cumulative Credits	44.85	45.84	0.99	530	44.17	44.73	0.56	475
Underclass	0.75	0.75	0.01	530	0.75	0.78	0.03	475
Part time	0.07	0.08	0.02	530	0.07	0.07	0.01	475
Demographic Characteristics								
Age	21.21	20.94	-0.27	530	21.22	20.71	-0.50 *	475
Female	0.44	0.47	0.03	530	0.43	0.45	0.03	475
Asian	0.48	0.38	-0.10 **	446	0.49	0.39	-0.10 **	398
Black, Hispanic, Other	0.31	0.31	-0.00	446	0.29	0.30	0.01	398
Native English Speaker	0.54	0.53	-0.01	450	0.53	0.54	0.01	400
p-value, joint χ^2-test		0.167				0.038		

Note: Statistical significance means between traditional (lectures twice per week) and hybrid (lectures once per week) tested using two-sample *t*-tests assuming equal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Hybrid on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample sizes are 195 (beginning) and 181 (ending) for the top panel and 530 (beginning) and 475 (ending) for the bottom panel.

Table 3
Student Performance

Covariate	Midterm, All (1)	Midterm, All (2)	Midterm, Finishers (3)	Midterm, Finishers (4)	Final (5)	Final (6)	Midterm + Final (7)	Midterm + Final (8)	Aplia (9)	Aplia (10)	Course Grade (11)	Course Grade (12)
Hybrid	-3.77 ***	-3.24 ***	-3.30 **	-3.26 ***	-2.42 *	-1.64	-2.80 **	-2.33 **	-0.99	-1.28	-2.86 **	-2.59 ***
	(1.45)	(1.16)	(1.43)	(1.16)	(1.32)	(1.10)	(1.24)	(0.97)	(1.75)	(1.48)	(1.24)	(0.96)
Mon.-Wed.	<.0.01	-1.09	0.23	-0.87	0.34	-1.02	0.29	-0.96	-1.50	-2.06	-0.03	-1.20
	(1.45)	(1.18)	(1.43)	(1.19)	(1.32)	(1.11)	(1.24)	(0.98)	(1.74)	(1.55)	(1.24)	(0.97)
Prof. A/Small Class		3.67 ***		2.78 ***		3.14 ***		2.98 ***		1.60		2.70 ***
		(1.14)		(1.14)		(1.10)		(0.95)		(1.56)		(0.96)
Other covariates		X		X		X		X		X		X
R^2	0.013	0.383	0.010	0.378	0.006	0.325	0.010	0.429	0.003	0.311	0.010	0.457
N	693		656		656		656		656		656	
Mean score, Trad.	73.17		74.16		60.98		66.63		78.66		82.93	
Standard Dev., Trad.	15.54		14.93		14.85		13.08		19.20		13.11	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Table 4
Student Performance within Professor / Classroom

Covariate	**Midterm, All** (1)	(2)	**Final** (3)	(4)	**Midterm + Final** (5)	(6)	**Aplia** (7)	(8)	**Course Grade** (9)	(10)
Professor A / Small Classroom										
Hybrid	-3.71	-2.82	-2.69	-0.28	-3.01	-1.33	0.57	0.24	-2.76	-1.57
	(2.46)	(2.19)	(2.23)	(2.05)	(2.13)	(1.85)	(2.92)	(2.47)	(2.12)	(1.77)
Other covariates		X		X		X		X		X
R^2	0.012	0.460	0.008	0.415	0.011	0.490	<0.001	0.338	0.009	0.503
N	184		181		181		181		181	
Mean score, Trad.	76.16		63.61		69.13		79.34		85.11	
Std. Dev., Trad.	16.01		14.51		13.91		21.21		13.96	
Professor B / Large Classroom										
Hybrid	-3.70 **	-4.50 ***	-2.04	-2.62 **	-2.47 **	-3.39 ***	-2.47	-3.38 **	-2.86 **	-3.87 ***
	(1.48)	(1.22)	(1.37)	(1.22)	(1.23)	(1.00)	(1.90)	(1.64)	(1.27)	(1.00)
Other covariates		X		X		X		X		X
R^2	0.012	0.365	0.005	0.302	0.008	0.417	0.004	0.338	0.011	0.459
N	509		475		475		475		475	
Mean score, Trad.	72.04		59.95		65.65		78.39		82.07	
Std. Dev., Trad.	14.51		14.89		12.64		18.39		12.69	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus. Capacity of the small classroom is 114 students whle the large classroom is 274 students.

Table 5
Student Performance within Class Day

Covariate	**Midterm, All** (1)	(2)	**Final** (3)	(4)	**Midterm + Final** (5)	(6)	**Aplia** (7)	(8)	**Course Grade** (9)	(10)
					Monday - Wednesday Classes					
Hybrid	-7.83 ***	-6.83 ***	-5.71 ***	-4.46 ***	-5.95 ***	-5.05 ***	-3.42	-2.51	-5.90 ***	-4.96 ***
	(2.00)	(1.57)	(1.79)	(1.40)	(1.71)	(1.25)	(2.65)	(2.24)	(1.74)	(1.25)
Other Covariates		X		X		X		X		X
R^2	0.037	0.434	0.029	0.409	0.035	0.495	0.005	0.365	0.032	0.524
N	355		334		334		334		334	
Mean Score, Trad.	76.16		63.61		69.13		79.34		85.11	
Std. Dev., Trad.	16.01		14.51		13.91		21.21		13.96	
					Tuesday-Thursday Classes					
Hybrid	0.42	1.07	0.98	1.62	0.47	0.85	1.53	1.22	0.28	0.49
	(2.05)	(1.78)	(1.91)	(1.78)	(1.76)	(1.55)	(2.25)	(2.05)	(1.75)	(1.53)
Other Covariates		X		X		X		X		X
R^2	<0.001	0.340	0.001	0.298	<0.001	0.386	0.001	0.288	<0.001	0.404
N	338		322		322		322		322	
Mean Score, Trad.	72.04		59.95		65.65		78.39		82.07	
Std. Dev., Trad.	16.01		14.89		12.64		18.39		12.69	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean scores are for students in the traditional format. Midterm, Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Table 6
Interaction Effects on the Combined Midterm and Final

Grade Point Average			**Sex**			**Race and Ethnicity**			**Native English Speaker?**			**Hours Worked Per Week**		
Category	(1)	(2)	**Category**	(3)	(4)	**Category**	(5)	(6)	**Category**	(7)	(8)	**Category**	(9)	(10)
< Median	ref.		Male	ref.		White	ref.		No	ref.		None	ref.	
≥ Median	-0.49	-0.75	Female	-0.01	0.74	Asian	3.76	0.34	Yes	2.62	2.06	1-30 hrs	-4.30	-2.44
	(1.97)	(1.73)		(2.14)	(1.68)		(2.77)	(2.14)		(2.38)	(1.83)		(2.66)	(2.01)
						Black/ Hisp./Oth.	1.66	-0.09				> 30 hrs	-5.86	-2.73
							(3.08)	(2.38)					(4.18)	(3.50)
Missing	1.85	1.35				Missing	2.35	-1.50	Missing	-0.84	-3.22	Missing	-0.56	-1.81
	(4.35)	(3.96)					(3.64)	(2.81)		(2.91)	(2.43)		(4.12)	(3.54)
Covariates		X	Covariates		X	Covariates		X	Covariates		X	Covariates		X
p for joint χ^2	0.855	0.814				*p* for joint χ^2	0.587	0.922	*p* for joint χ^2	0.380	0.066	*p* for joint χ^2	0.284	0.669
R^2	0.223	0.436	R^2	0.032	0.429	R^2	0.052	0.430	R^2	0.019	0.433	R^2	0.075	0.444

Note: Outcome is the combined midterm plus final scaled to 100 points. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Coefficients reported are for the interaction with Hybrid of the indicated category. All regressions also include a main effect for Hybrid and for the indicated categories. All regressions include a dummy variable for Monday-Wednesday class meeting and a main effect for Hybrid. Regressions with covariates include, where appropriate Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. The reported *p*-values are from χ^2 tests that the reported interactions with Hybrid are jointly equal to zero. The sample size for each regression is 656. In columns (1) and (2) the measure used to stratify is the median of Baruch GPA/Predicted Baruch GPA. We use the Baruch GPA for students who have one, and predicted Baruch GPA for students who do not have Baruch GPA, but have a Transfer GPA. Predicted Baruch GPA is calculated from a regression of Baruch GPA on a quadratic in Transfer GPA, a quadratic in Age, Cumulative Credits, and indicators variables for Female and Underclassman for the 148 students who have both a Baruch GPA and a Transfer GPA. There are 51 students who have neither a

Table 7
Attendance, Attrition, and Online Usage

Covariate	Percentage Attended (1)	Percentage Attended (2)	Number of Videos (3)	Number of Videos (4)	Hours on Aplia (5)	Hours on Aplia (6)	Withdrew Any Time (7)	Withdrew Any Time (8)	Withdrew After Midterm (9)	Withdrew After Midterm (10)
Hybrid	1.21	0.98	1.82	2.52 *	0.45	0.29	0.007	0.005	0.016	0.009
	(1.11)	(1.11)	(1.76)	(1.50)	(2.48)	(2.19)	(1.425)	(0.023)	(0.015)	(0.016)
Mon.-Wed.	-1.91	-2.23 **	-0.16	-0.65	2.91	3.34	-0.014	-0.015	0.004	0.012
	(1.11)	(1.12)	(1.75)	(1.56)	(2.47)	(2.32)	(0.023)	(0.023)	(0.015)	(0.014)
Prof. A/Small Class		2.03 *		8.58 ***		-2.07		-0.034		-0.053 ***
		(1.09)		(1.60)		(2.34)		(0.024)		(0.015)
Other covariates		X		X		X		X		X
R^2	0.004	0.104	0.003	0.177	0.003	0.182	<0.001	0.069	0.002	0.065
N	656		656		656		725		693	
Mean Outcome, Trad.	85.02		8.54		44.26		0.095		0.044	
Std. Dev., Trad.	12.46		12.46		27.64		0.293		0.206	

Note: Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. Percentage Attended is on a 100-point scale. Other covariates are Baruch GPA, Transfer, GPA, Verbal SAT, Math SAT, Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Mean outcomes are for students in the traditional format. 69 students in total withdrew at any time during the course, and 27 withdraw after the midterm. Withdrawal after the midterm is conditional on having taken the midterm.

Table 8
Non-Experimental and Experimental Estimates of Student Performance

	Final		**Midterm + Final**		**Course Grade**	
	Non-Experi-mental	**Experi-mental**	**Non-Experi-mental**	**Experi-mental**	**Non-Experi-mental**	**Experi-mental**
Covariate	(1)	(2)	(3)	(4)	(5)	(6)
Number of Classes Attended	0.58 *** (0.21)		0.47 *** (0.15)		0.90 *** (0.17)	
Hybrid		-1.45 (1.09)		-2.03 ** (0.95)		-2.11 ** (0.94)
Prof. A/Small Class	2.82 * (1.47)	3.51 *** (1.09)	2.67 ** (1.28)	3.36 *** (0.95)	2.17 * (1.19)	3.11 *** (0.95)
Monday-Wednesday		-0.95 (1.10)		-0.96 (0.96)		-1.25 (0.96)
Baruch GPA/ Predicted Baruch GPA	11.38 *** (1.31)	11.24 *** (0.95)	10.89 *** (1.19)	11.37 *** (0.85)	11.23 *** (1.17)	13.14 *** (0.89)
Verbal SAT/100	1.34 (1.11)	1.06 (0.76)	1.20 (0.92)	0.50 (0.62)	0.76 (0.85)	-0.20 (0.62)
Math SAT/100	2.66 ** (1.27)	3.73 *** (0.86)	3.44 *** (1.09)	4.58 *** (0.72)	2.76 *** (1.03)	4.06 *** (0.73)
R^2	0.381	0.334	0.454	0.434	0.511	0.456
N	325	656	325	656	325	656
Mean outcome	60.98	59.84	66.63	65.29	82.93	81.48
Std. Dev. of outcome	14.85	15.07	13.08	13.78	13.11	81.48
Effect of Increase of 11 Classes	6.41 *** (2.31)	1.45 (1.09)	5.14 *** (1.70)	2.03 ** (0.95)	9.85 *** (1.85)	2.11 ** (0.94)

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors in parentheses. Significance levels are indicated by * <.10, ** <.05, *** <.01. All models also Cumulative Credits, Age, indicator variables for Part-Time Student, Underclassman, Female, Asian, Black/Hispanic/Other, and Native Speaker plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race, and Native English Speaker. Final, and Midterm+Final are raw (uncurved) scores. Aplia is average score on online quizzes. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus. Predicted Baruch GPA is calculated from a regression of Baruch GPA on a quadratic in Transfer GPA, a quadratic in Age, Cumulative Credits, and indicators variables for Female and Underclassman for the 148 students who have both a Baruch GPA and a Transfer GPA. There are 51 students who have neither a Baruch GPA nor a Predicted Baruch GPA. The difference in median classes attended between the traditional and hybrid sections was 11 (22 in the traditional, 11 in the hybrid); the difference in mean classes attended between the traditional and hybrid formats was 11.01 (22.25 in the traditional and 10.24 in the hybrid).

Appendix Table 1
Baseline Characteristics of Participants at the Beginning and End of the Semester by Instruction Day

Covariate	Beginning Sample: Traditional	Beginning Sample: Hybrid	Beginning Sample: Hybrid-Trad.	Beginning Sample: *N*	Ending Sample: Traditional	Ending Sample: Hybrid	Ending Sample: Hybrid-Trad.	Ending Sample: *N*
				Monday-Wednesday				
Prior Academic Performance								
Baruch GPA	3.06	3.05	-0.01	286	3.08	3.10	0.02	260
Transfer GPA	3.37	3.23	-0.14	127	3.42	3.26	-0.16 *	109
SAT Verbal	543.52	537.78	-5.74	283	545.61	543.38	-2.22	138
SAT Math	609.01	596.75	-12.27	283	614.39	602.72	-11.68	138
Prior Academic Experience								
Cumulative Credits	48.80	45.84	-2.96	367	47.94	44.73	-3.22	334
Underclass	0.67	0.75	0.08	367	0.70	0.78	0.08	334
Part time	0.11	0.08	-0.03	367	0.12	0.07	-0.05	334
Demographic Characteristics								
Age	21.26	20.94	-0.33	367	21.27	20.71	-0.56	334
Female	0.48	0.47	-0.01	367	0.48	0.45	-0.02	334
Asian	0.36	0.38	0.01	315	0.39	0.39	-0.00	286
Black, Hispanic, Other	0.30	0.31	0.00	315	0.26	0.30	0.04	286
Native English Speaker	0.54	0.53	-0.01	317	0.52	0.54	0.02	286
p-value, joint χ^2-test		0.551				0.450		
				Tuesday-Thursday				
Prior Academic Performance								
Baruch GPA	2.98	2.89	-0.09	282	2.98	2.95	-0.03	258
Transfer GPA	3.29	3.32	0.03	138	3.31	3.31	0.01	121
SAT Verbal	540.86	520.67	-20.19	273	544.38	520.14	-24.24	250
SAT Math	599.34	594.53	-4.81	273	604.83	596.11	-8.72	250
Prior Academic Experience								
Cumulative Credits	44.85	42.58	-2.28	358	44.17	41.87	-2.30	322
Underclass	0.75	0.81	0.07	358	0.75	0.82	0.07	322
Part time	0.07	0.05	-0.01	358	0.07	0.04	-0.02	322
Demographic Characteristics								
Age	21.21	20.89	-0.31	358	21.22	20.67	-0.54	475
Female	0.44	0.48	0.04	358	0.43	0.47	0.04	475
Asian	0.48	0.58	0.11	291	0.49	0.58	0.09	398
Black, Hispanic, Other	0.31	0.18	-0.13 **	291	0.29	0.17	-0.12 **	398
Native English Speaker	0.54	0.51	-0.03	304	0.53	0.50	-0.03	400
p-value, joint χ^2-test		0.366				0.080		

Note: Statistical significance means between traditional (lectures twice per week) and hybrid (lectures once per week) tested using two-sample *t*-tests assuming equal variances. Significance levels are indicated by * <.10, ** <.05, *** <.01. The joint χ^2 tests are based on logit regressions of Hybrid on all variables shown in the table plus indicator variables for missing Baruch GPA, Transfer GPA, SAT scores, Race/Ethnicity, and Native English Speaker. Sample sizes are 367 (beginning) and 334 (ending) for the top panel and 358 (beginning) and 322 (ending) for the bottom panel.

Appendix Table 2
Regression Coefficients for Student Outcomes, Table 3

Outcome:	**Midterm, All**		**Midterm, Finishers**		**Final**		**Midterm + Final**		**Aplia**		**Course Grade**	
Table 3 Column:	**(2)**		**(4)**		**(6)**		**(8)**		**(10)**		**(12)**	
Covariate	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**	**Coeff**	**Std. Err.**
Hybrid	-3.238	1.159	-3.263	1.155	-1.636	1.101	-2.334	0.968	-1.276	1.476	-2.587	0.957
Monday-Wednesday	-1.088	1.181	-0.871	1.186	-1.019	1.114	-0.955	0.978	-2.056	1.546	-1.201	0.973
Professor A/Small Classroom	3.670	1.142	2.776	1.140	3.138	1.100	2.983	0.954	1.600	1.562	2.696	0.959
Verbal SAT/100	0.354	0.713	0.173	0.696	1.102	0.804	0.704	0.644	-1.830	1.011	0.169	0.632
Math SAT/100	6.494	0.803	6.148	0.824	3.896	0.859	4.861	0.721	2.949	1.162	4.442	0.722
Missing SAT scores	-4.035	1.861	-3.607	1.841	0.862	1.860	-1.053	1.596	0.796	2.261	-0.771	1.563
Baruch GPA	11.187	1.099	11.456	1.123	10.323	1.001	10.809	0.909	17.476	1.669	12.816	0.981
Missing Baruch GPA	2.188	1.551	2.996	1.568	2.238	1.603	2.563	1.357	4.885	1.869	3.275	1.315
Transfer GPA	9.542	2.441	7.895	2.388	7.257	2.613	7.530	2.126	8.665	2.713	7.662	1.910
Missing Transfer GPA	-0.517	1.728	-0.530	1.702	2.419	1.816	1.155	1.476	-2.086	2.467	0.364	1.482
Cumulative Credits	-0.023	0.044	-0.017	0.045	-0.040	0.042	-0.030	0.036	-0.229	0.062	-0.068	0.036
Underclassman	-1.796	2.116	-1.398	2.157	-2.355	2.121	-1.945	1.769	-6.786	2.765	-2.838	1.701
Part time	-2.793	2.569	-2.622	2.582	1.186	2.179	-0.446	2.099	-5.128	3.537	-1.220	2.176
Age	-0.372	0.262	-0.377	0.282	0.062	0.220	-0.126	0.214	0.436	0.268	-0.006	0.192
Female	-2.625	1.071	-3.166	1.053	-4.130	1.022	-3.717	0.862	-1.129	1.390	-3.112	0.852
Asian	-1.309	1.417	-0.988	1.410	-0.320	1.341	-0.606	1.119	0.431	1.897	-0.520	1.103
Black/Hispanic/Other	-1.926	1.596	-1.614	1.565	-1.241	1.462	-1.401	1.252	-3.820	2.159	-2.283	1.279
Missing Race	2.658	1.773	2.552	1.808	1.594	1.811	2.005	1.505	2.087	2.433	1.674	1.479
Native English Speaker	-0.070	1.223	0.059	1.207	-2.192	1.174	-1.227	1.003	-0.169	1.706	-1.088	1.008
Missing Language	0.885	1.576	-0.431	1.612	-2.297	1.539	-1.498	1.277	-2.118	1.979	-1.646	1.245
Constant	-20.679	10.714	-12.576	10.455	-20.953	11.740	-17.363	9.671	-2.184	13.771	-1.834	9.043
R^2	0.383		0.378		0.325		0.429		0.311		0.457	
N	693		656		656		656		656		656	

Note: All outcomes are based on a 100-point scale. Estimated with OLS. Heteroskedasticity-consistent standard errors. Course Grade includes curved midterm and final grades, penalties for missed classes, and the 5 percentage point participation bonus.

Appendix: Midterm and Final Exams

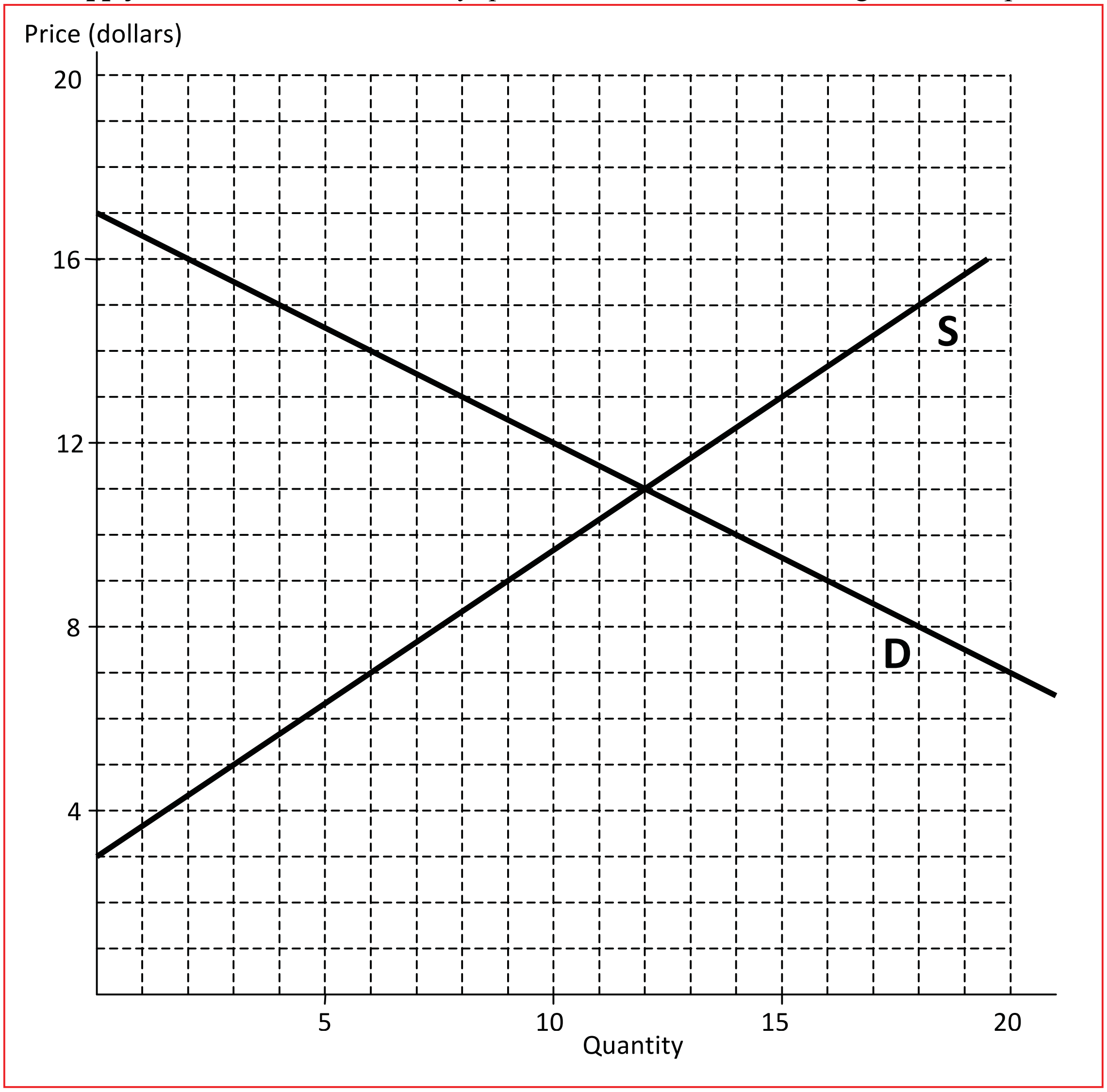
The same exams, with questions randomly ordered, were given in both formats.

Name:____________________________ Class:______________ Date: _____________ ID: A

Exam 1 Fall 2013-14

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

Figure: Supply and Demand. Treat every question that references this figure as independent.



1. **Refer to *Figure: Supply and Demand***. If a price floor of $13 is imposed on this market, what is the likely effect?

a. A surplus of 7 units
b. A shortage of 7 units
c. A surplus of 5 units
d. Nothing, the price floor is not binding.

2. **Refer to *Figure: Supply and Demand***. What is consumer surplus in equilibrium?
a. $24
b. $36
c. $48
d. $72

3. **Refer to *Figure: Supply and Demand***. If there is a $7 per unit negative externality associated with the consumption of this good, what is total surplus after the socially optimal tax is implemented?
a. $21
b. $36
c. $42
d. $54

4. **Refer to *Figure: Supply and Demand***. How much tax revenue is generated by a $7 per unit tax?
a. $28
b. $35
c. $42
d. $49

Table: Production. Assume that the farmer and the rancher can switch between producing meat and producing potatoes at a constant rate.

	Labor Hours Needed to Make 1 Pound of		Pounds Produced in 24 Hours	
	Meat	Potatoes	Meat	Potatoes
Farmer	8	2	3	12
Rancher	3	6	8	4

5. **Refer to *Table: Production***. Assume that the farmer and the rancher each have 24 labor hours available. If each person divides his time equally between the production of meat and potatoes, then total production is
a. 3 pounds of meat and 12 pounds of potatoes.
b. 5.5 pounds of meat and 8 pounds of potatoes.
c. 8 pounds of meat and 4 pounds of potatoes.
d. 11 pounds of meat and 16 pounds of potatoes.

6. **Refer to *Table: Production*.** Which of the following statements is correct?
a. The farmer has an absolute advantage in potato production but a comparative advantage in meat production.
b. The farmer has an absolute advantage in meat production but a comparative advantage in potato production.
c. The farmer has both an absolute advantage and comparative advantage in meat production.
d. The farmer has both an absolute advantage and comparative advantage in potato production.

Name:____________________________ Class:______________ Date: _____________ ID: A

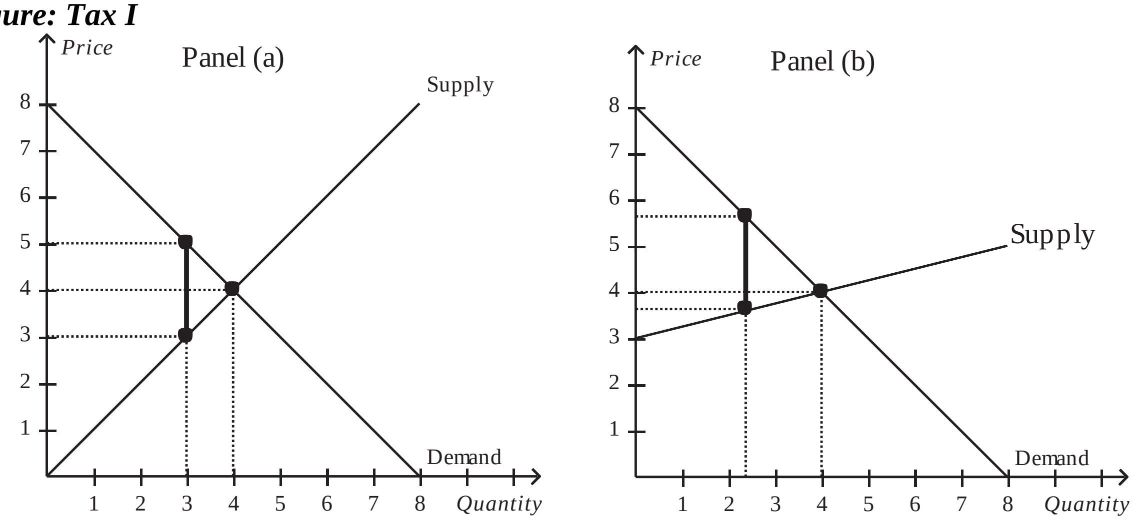
Table: Willingness to Pay
Consider the town of Anywhere with only three residents, Mary, Bill, and Tricia. The three residents are trying to determine how large, in acres, they should build the public park. The table below shows each resident's willingness to pay for each acre of the park.

Acres	Mary	Bill	Tricia
1	$14	$18	$30
2	10	14	26
3	6	10	22
4	4	6	18
5	2	3	14
6	0	1	10
7	0	0	6

7. **Refer to *Table: Willingness to Pay*.** Suppose the cost to build the park is $33 per acre. How many acres maximizes total surplus from the park in Anywhere?

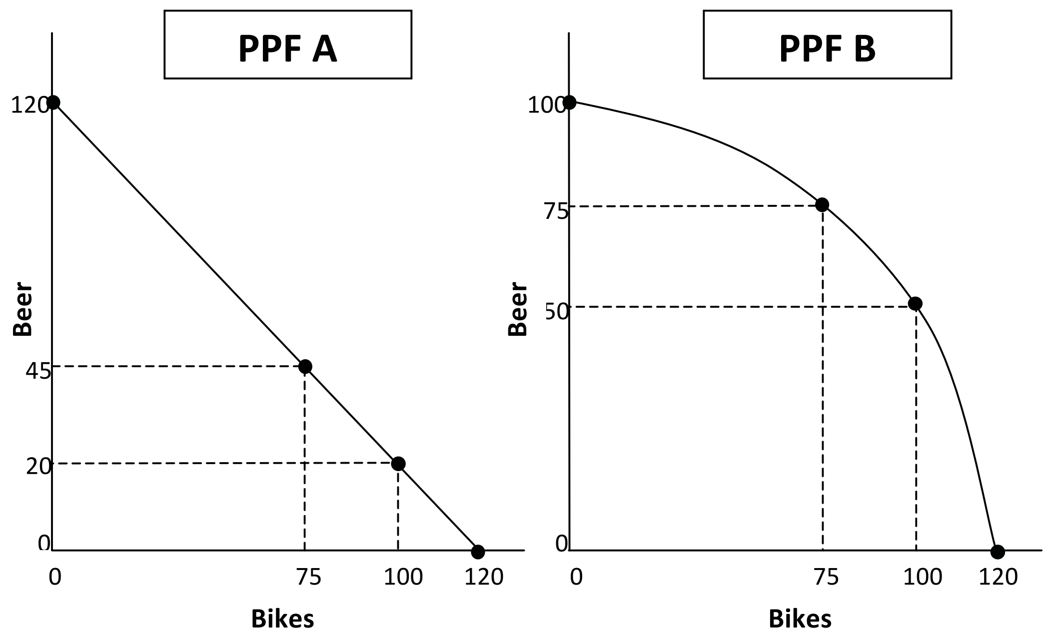
a. 2 acres
b. 3 acres
c. 4 acres
d. 5 acres

Figure: Tax I



8. **Refer to *Figure: Tax I.*** Panel (a) and Panel (b) each illustrate a $2 tax placed on a market. In comparison to Panel (b), Panel (a) illustrates which of the following statements?
a. When demand is relatively inelastic, the deadweight loss of a tax is smaller than when demand is relatively elastic.
b. When demand is relatively elastic, the deadweight loss of a tax is larger than when demand is relatively inelastic.
c. When supply is relatively inelastic, the deadweight loss of a tax is smaller than when supply is relatively elastic.
d. When supply is relatively elastic, the deadweight loss of a tax is larger than when supply is relatively inelastic.

Figure: PPF



9. **Refer to *Figure: PPF***. What is the opportunity cost of 25 additional beers on PPF B when the country is currently making 100 bikes?
a. 20 bikes
b. 25 bikes
c. 50 bikes
d. 75 bikes

10. **Refer to *Figure: PPF***. Which of the following statements is correct if 100 bikes are efficiently produced on both PPFs?
a. PPF B reflects a comparative advantage in making beer.
b. PPF B reflects a comparative advantage in making bikes.
c. The opportunity cost of making a bike is the same on both PPFs.
d. PPF B reflects an absolute advantage in making bikes.

11. Before the flu season begins, Jeremy gets a flu shot. As a result, Jeremy and several of his friends and relatives avoid the flu for the entire flu season. It would make sense to argue that
a. flu shots provide a positive externality, and that flu shots should be subsidized.
b. if flu shots are not subsidized, then the number of people getting flu shots will be smaller than the socially optimal number.
c. the externality generated by flu shots is more like the externality generated by education than the externality generated by pollution.
d. All of the above are correct.

12. Equilibrium quantity must decrease when demand
a. increases and supply does not change, when demand does not change and supply decreases, and when both demand and supply decrease.
b. increases and supply does not change, when demand does not change and supply increases, and when both demand and supply decrease.
c. decreases and supply does not change, when demand does not change and supply increases, and when both demand and supply decrease.
d. decreases and supply does not change, when demand does not change and supply decreases, and when both demand and supply decrease.

Scenario: International Trade: Let $P_d = 100\text{-}3Q_d$ be domestic demand for backpacks and let $P_s\text{=}20\text{+}2Q_s$ be domestic supply in a small country. The world price of backpacks is $70.

13. **Refer to *Scenario: International Trade*.** What is the domestic equilibrium price if there is no free trade?
a. $16
b. $36
c. $52
d. $64

14. **Refer to *Scenario: International Trade*.** Assume this country allows trade. At the world price there will be
a. imports of 15 units.
b. exports of 25 units.
c. exports of 15 units.
d. exports of 10 units.

15. **Refer to *Scenario: International Trade*.** The increase in total surplus as a result of trade is
a. $200
b. $135
c. $270
d. $80

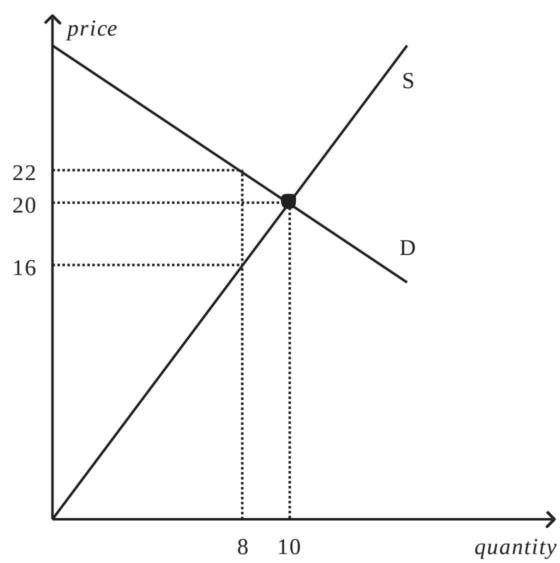
16. **Refer to *Scenario: International Trade*.** Because of the great recession the world price falls to $40. As a result
a. exports fall by 5 units and total surplus declines.
b. the country imports 10 units and consumer surplus rises.
c. the country imports 25 units and consumer surplus rises.
d. domestic production falls 5 units and producer surplus falls.

Name:____________________________ Class:______________ Date: _____________ ID: A

17. **Refer to *Scenario: International Trade*.** Given a world price of $40, the government decides to protect domestic producers by imposing a tariff of $6. As a result

a. imports decline by 5 units and producer surplus rises.
b. exports rise by 5 units and producer surplus rises.
c. imports decline by 10 units and consumer surplus falls.
d. domestic production rises by 13 units.

Figure: Tax II



18. **Refer to *Figure: Tax II*.** Suppose a tax of $3 per unit is imposed on this market. What will be the new equilibrium quantity in this market?

a. Less than 8 units.
b. 8 units.
c. Between 8 units and 10 units.
d. Greater than 10 units.

19. **Refer to *Figure: Tax II*.** Suppose a tax of $3 per unit is imposed on this market. How much will sellers receive per unit after the tax is imposed?

a. $16
b. Between $16 and $20.
c. Between $20 and $22.
d. $22

20. Your neighbor owns an apple tree, and some of the apples drop into your yard. You don't like to eat apples, and the fallen apples make your yard more difficult to mow and ruin your grass. Your neighbor values the apple tree at $1,000, and your costs associated with the tree are $2,500. Suppose your neighbor has the legal right to keep the tree under any circumstances. If there are no transactions costs to negotiating with your neighbor, what is the likely outcome in

this situation according to the Coase theorem?
a. You call the Department of Public Works to have the tree cut down.
b. You pay your neighbor $2,000 to cut the tree down.
c. Your neighbor pays you $1,500 to not have the tree cut down.
d. Your neighbor pays you $500 to not have the tree cut down.

21. If a shortage exists in a market, then we know that the actual price is
a. above the equilibrium price, and quantity supplied is greater than quantity demanded.
b. above the equilibrium price, and quantity demanded is greater than quantity supplied.
c. below the equilibrium price, and quantity demanded is greater than quantity supplied.
d. below the equilibrium price, and quantity supplied is greater than quantity demanded.

22. A cable television broadcast of a movie is
a. excludable and rival in consumption.
b. excludable and not rival in consumption.
c. not excludable and rival in consumption.
d. not excludable and not rival in consumption.

Table: Clean-up Costs
The following table shows the marginal (not total) costs for each of four firms (A, B, C, and D) to eliminate units of pollution from their production processes. For example, for Firm A to eliminate one unit of pollution, it would cost $60, and for Firm A to eliminate a second unit of pollution would cost an additional $70 (that is, reduction of two units costs a total of $130).

	Firm			
Unit to be eliminated	A	B	C	D
First unit	60	57	54	62
Second unit	70	75	72	73
Third unit	82	86	82	91
Fourth unit	107	108	107	111

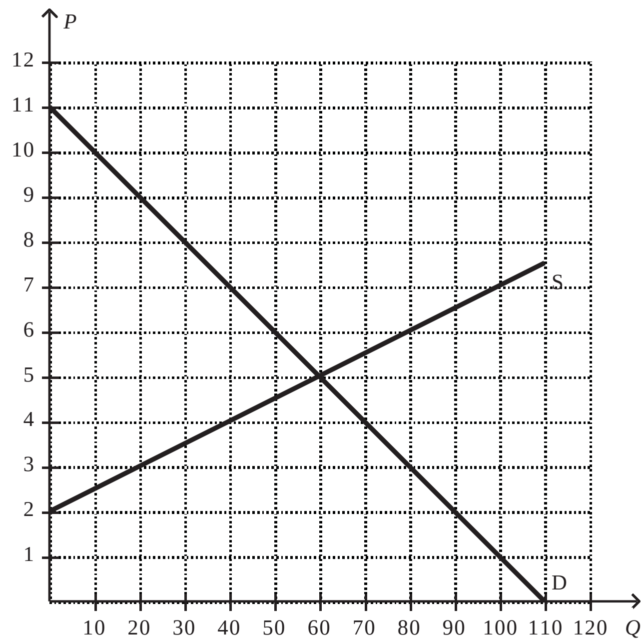
23. **Refer to *Table: Clean-up Costs*.** If the government charged a fee of $74 per unit of pollution, how many units of pollution would the firms eliminate altogether?
a. 7 units
b. 8 units
c. 9 units
d. 10 units

24. When the price of good X is $15, the quantity demanded of good Y is 2,000 units per week. When the price of good X is $10, the quantity demanded of good Y is 3,000 units per week. What are these goods?
a. Normal goods
b. Inferior goods
c. Substitutes
d. Complements

25. When the price of an eBook is $15.00, the quantity demanded is 400 eBooks per day. When the price falls to $10.00, the quantity demanded increases to 700. Given this information and using the midpoint method, we know that the demand for eBooks is

a. inelastic.
b. elastic.
c. unit elastic
d. perfectly inelastic

Figure: Tax III



26. **Refer to *Figure: Tax III*.** Suppose the government changed the per-unit tax on this good from $3.00 to $1.50. Compared to the original tax rate, this lower tax rate would

a. increase tax revenue and increase the deadweight loss from the tax.
b. increase tax revenue and decrease the deadweight loss from the tax.
c. decrease tax revenue and increase the deadweight loss from the tax.
d. decrease tax revenue and decrease the deadweight loss from the tax.

27. Suppose that a worker in Caninia can produce either 2 blankets or 8 meals per day, and a worker in Felinia can produce either 5 blankets or 1 meal per day. Each nation has 10 workers. For many years, the two countries traded, each completely specializing according to their respective comparative advantages. Now war has broken out between them and all trade has stopped. Without trade, Caninia produces and consumes 10 blankets and 40 meals per day and Felinia produces and consumes 25 blankets and 5 meals per day. The war has caused the combined daily output of the two countries to decline by

a. 15 blankets and 35 meals.
b. 25 blankets and 40 meals.
c. 35 blankets and 45 meals.
d. 50 blankets and 80 meals.

28. Suppose that demand is inelastic within a certain price range. For that price range,
a. an increase in price would increase total revenue because the decrease in quantity demanded is proportionately less than the increase in price.
b. an increase in price would decrease total revenue because the decrease in quantity demanded is proportionately greater than the increase in price.
c. a decrease in price would increase total revenue because the increase in quantity demanded is proportionately smaller than the decrease in price.
d. a decrease in price would not affect total revenue.

Table: Willingness to Pay
For each of three potential buyers of apples, the table displays the willingness to pay for the first three apples of the day. Assume Xavier, Yadier, and Zavi are the only three buyers of apples, and only three apples can be supplied per day.

	First Apple	**Second Apple**	**Third Apple**
Xavier	\$1.75	\$1.55	\$1.15
Yadier	\$1.50	\$1.25	\$0.75
Zavi	\$1.30	\$1.10	\$0.70

29. **Refer to *Table: Willingness to Pay*.** If the market price of an apple is \$1.40, then the market quantity of apples demanded per day is
a. 1 unit
b. 2 units
c. 3 units
d. 4 units

30. **Refer to *Table: Willingness to Pay*.** If the market price of an apple is \$1.40, then consumer surplus amounts to
a. \$0.60
b. \$1.20
c. \$1.40
d. \$3.40

Name:_____________________________ Class:______________ Date: _____________ ID: A

Exam 1 Fall 2013-14
Answer Key

Multiple Choice

QUESTION	ANSWER	DIFFICULTY	REFERENCE CHAPTER
1.	A	1/3	6
2.	B	2/3	7
3.	A	2/3	8
4.	C	2/3	8
5.	B	2/3	2
6.	D	1/3	3
7.	B	2/3	11
8.	C	2/3	8
9.	B	2/3	2
10.	A	3/3	3
11.	D	1/3	10
12.	D	2/3	4
13.	C	2/3	4
14.	C	3/3	9
15.	B	3/3	9
16.	B	3/3	9
17.	A	3/3	9
18.	C	1/3	6
19.	B	2/3	6
20.	B	2/3	10
21.	C	1/3	4
22.	B	1/3	11
23.	A	2/3	10
24.	D	2/3	5
25.	B	2/3	5
26.	D	2/3	8
27.	A	2/3	3
28.	A	2/3	5
29.	C	1/3	7
30.	A	2/3	7

Name:__________________________ Class:______________ Date: _____________ ID: A

Final Exam, Fall 2013-14

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

Table: Income Tax Rates for a Single Individual

2009 Tax Rates	Income Ranges	2010 Tax Rates	Income Ranges
15%	$0 – $28,000	10%	$0 – $10,000
25%	$28,000 – $60,000	15%	$10,000 – $30,000
31%	$60,000 – $140,000	27%	$30,000 – $80,000
36%	$140,000 – $300,000	33%	$80,000 – $150,000
40%	over $300,000	38%	$150,000 – $320,000
		41%	over $320,000

1. ***Refer to Table: Income Tax Rates for a Single Individual***. Mia is a single person whose taxable income is $100,000 a year. What happened to her average tax rate from 2009 to 2010?
a. It increased.
b. It decreased.
c. It stayed the same.
d. We don’t have enough information to answer this question.

2. ***Refer to Table: Income Tax Rates for a Single Individual***. Mia is a single person whose taxable income is $100,000 a year. What happened to her marginal tax rate from 2009 to 2010?
a. It increased.
b. It decreased.
c. It stayed the same.
d. We don’t have enough information to answer this question.

Scenario: Costs. Ellie has been working for an engineering firm and earning an annual salary of $80,000. She decides to open her own engineering business. Her annual expenses will include $15,000 for office rent, $3,000 for equipment rental, $1,000 for supplies, $1,200 for utilities, and a $35,000 salary for a secretary/bookkeeper. Ellie will cover her start-up expenses by cashing in a $20,000 certificate of deposit on which she was earning annual interest of $500, by the time this money is spent she will have enough revenue from her new business to cover expenses.

3. ***Refer to Scenario: Costs.*** Ellie’s accounting costs for the first year will be
a. $55,200
b. $75,700
c. $135,700
d. $155,700

4. ***Refer to Scenario: Costs.*** Ellie’s economic costs for the first year will be
a. $55,200
b. $75,700
c. $135,700
d. $155,700

Name:__________________________ **Class:**_______________ **Date:** ______________ **ID: A**

Scenario: Perfect Competition I. Suppose a firm's fixed costs are \$50 and its marginal cost of producing q units is MC = 10 + 2q. The industry demand curve is given by $P = 40 - Q_D$ (where quantity is given in thousands of units).

5. ***Refer to Scenario: Perfect Competition I.*** If the firm operates in a perfectly competitive industry and the price of the good is \$30, what is this firm's optimal short-run quantity?

a. 10 units
b. 0 units
c. 6 units
d. 15 units

6. ***Refer to Scenario: Perfect Competition I.*** If the firm operates in a perfectly competitive industry and the price of the good is \$30, how many firms produce this good in the short run?

a. 500
b. 800
c. 1,000
d. 1,200

7. Suppose a monopolistically competitive firm operates in the short run at a price above its average total cost of production. In the long run, the firm should expect

a. new firms to enter the market.
b. the market price to fall.
c. its prices to fall.
d. All of the above are correct.

Scenario: Forest. Four brothers share a forest with 2,000 acres of trees. To preserve the forest, the government promises to pay the group \$400,000 minus \$200 per acre of trees that has been cut down (this money will be split evenly among the brothers). Each brother can cut down and sell trees for \$100 per acre.

8. ***Refer to Scenario: Forest.*** What total quantity of cut tree acres maximizes the profit of the group? **Difficulty 2/3**

a. 0 acres
b. 100 acres
c. 1,000 acres
d. 2,000 acres

9. ***Refer to Scenario: Forest.*** What is the symmetric Nash equilibrium quantity of cut tree acres per individual? **Difficulty 2/3**

a. 0 acres
b. 100 acres
c. 1,000 acres
d. 500 acres

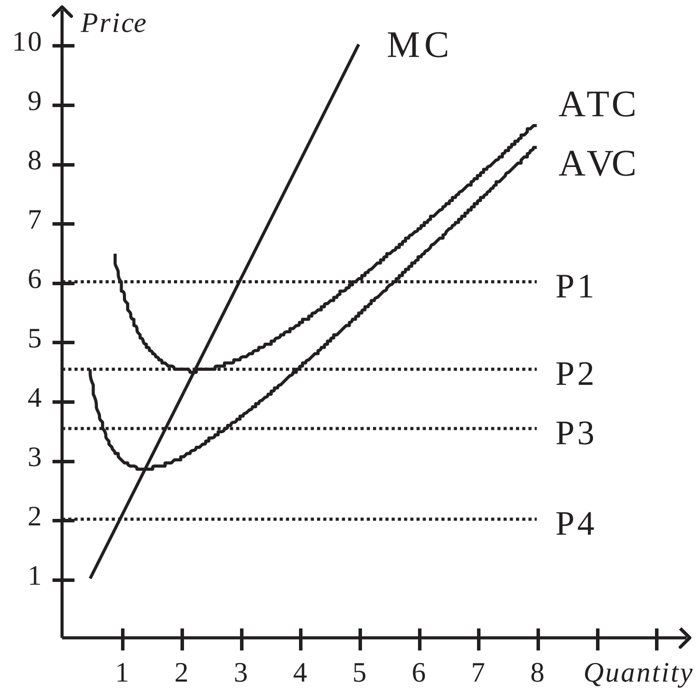
10. ***Refer to Scenario: Forest.*** Which phrase best describes the forest in this scenario? **Difficulty 1/3**

a. Public good
b. Common resource
c. Private good
d. Natural monopoly / Club good

11. Suppose a firm must pay \$100 per day per worker. If the firm hires 1 worker, it can produce 25 units of output. If the firm hires 2 workers, it can produce 60 units of output. If the firm hires 3 workers, it can produce 95 units of output. And if the firm hires 4 workers, it can produce 120 units of output. For which worker does the firm experience diminishing marginal product of labor?

a. First worker
b. Second worker
c. Third worker
d. Fourth worker

Figure: Perfect Competition I.



12. ***Refer to Figure: Perfect Competition I.*** Suppose a firm in a competitive industry has the following cost curves. If the price if P1 in the short run, what will happen in the long run?
a. Nothing. The price is consistent with zero economic profits, so there is no incentive for firms to enter or exit the industry.
b. Individual firms will earn positive economic profits in the short run, which will entice other firms to enter the industry.
c. Individual firms will earn negative economic profits in the short run, which will cause some firms to exit the industry.
d. Because the price is below the firm's average variable costs, the firms will shut down.

Scenario: Perfect Competition II. Suppose a competitive firm is producing Q=500 units of output. The marginal cost of the 500th unit is $17, and the average total cost of producing 500 units is $12. The firm sells its output for $20.

13. ***Refer to Scenario: Perfect Competition II.*** At Q=500, the firm's profits equal
a. $1,000.
b. $4,000.
c. $7,000.
d. $10,000.

14. ***Refer to Scenario: Perfect Competition II.*** At Q=500, the firm should
a. increase output to increase economic profit.
b. decrease output to increase economic profit
c. profit is maximized at Q=500.
d. None of these answers is necessarily correct.

Table: Game I.

		Firm 2			
		W	**X**	**Y**	**Z**
Firm 1	**A**	(2,9)	(6,8)	(7,7)	(6,6)
	B	(5,4)	(8,5)	(6,4)	(5,3)
	C	(4,9)	(4,3)	(5,6)	(2,8)
	D	(3,3)	(7,4)	(4,3)	(7,3)

15. ***Refer to Game I.*** Which outcome is a Nash equilibrium of this game? **Difficulty 2/3**

a. (B,X)
b. (A,Y)
c. (C,W)
d. (D,Z)

16. ***Refer to Game I.*** A total of how many actions can be eliminated by the iterated deletion of dominated strategies?

a. 0
b. 1
c. 3
d. 6

Table: Monopoly

Price	Quantity
$8	300
$7	400
$6	500
$5	600
$4	700
$3	800
$2	900
$1	1,000

17. ***Refer to Table: Monopoly.*** The monopolist has fixed costs of $1,000 and has a constant marginal cost of $2 per unit. If the monopolist were able to perfectly price discriminate, how many units would it sell?

a. 500 units
b. 700 units
c. 900 units
d. 1,000 units

18. Consider two cigarette companies, PM Inc. and Brown Inc. If neither company advertises, the two companies split the market and earn $50 million each. If they both advertise, they again split the market, but profits are lower by $10 million since each company must bear the cost of advertising. If one company advertises while the other does not, the one that advertises attracts customers from the other. In this case, the company that advertises earns $60 million while the company that does not advertise earns only $30 million. What will the two companies do if they behave as individual profit maximizers?

a. Neither company will advertise.
b. Both companies will advertise.
c. One company will advertise, the other will not.
d. The question requires we know how many customers are stolen through advertising.

19. Regulating natural monopolies by making them set price equal to marginal cost would
a. cause the monopolist to operate at a loss.
b. result in less than optimal total surplus.
c. maximize producer surplus.
d. result in higher profits for the monopoly.

Table: Average Total Cost. Each entry in the table represents the average total cost (per unit) of producing the specified number of units.

Output	Small Factory	Medium Factory	Large Factory	Extra Large Factory
100 units	$125	$200	$325	$500
200 units	$85	$125	$190	$350
300 units	$80	$90	$100	$200
400 units	$120	$75	$80	$120
500 units	$200	$95	$70	$90
600 units	$390	$185	$110	$85
700 units	$625	$300	$180	$130
800 units	$900	$475	$325	$195

20. ***Refer to Table: Average Total Cost***. Which entry is NOT on the firm's long-run average total cost (LRATC) curve?
a. 200 units, LRATC = $85
b. 400 units, LRATC = $75
c. 600 units, LRATC = $110
d. 800 units, LRATC = $195

21. ***Refer to Table: Average Total Cost***. At which level of output does the firm first experience diseconomies of scale in the long run?
a. 300 units
b. 500 units
c. 600 units
d. 800 units

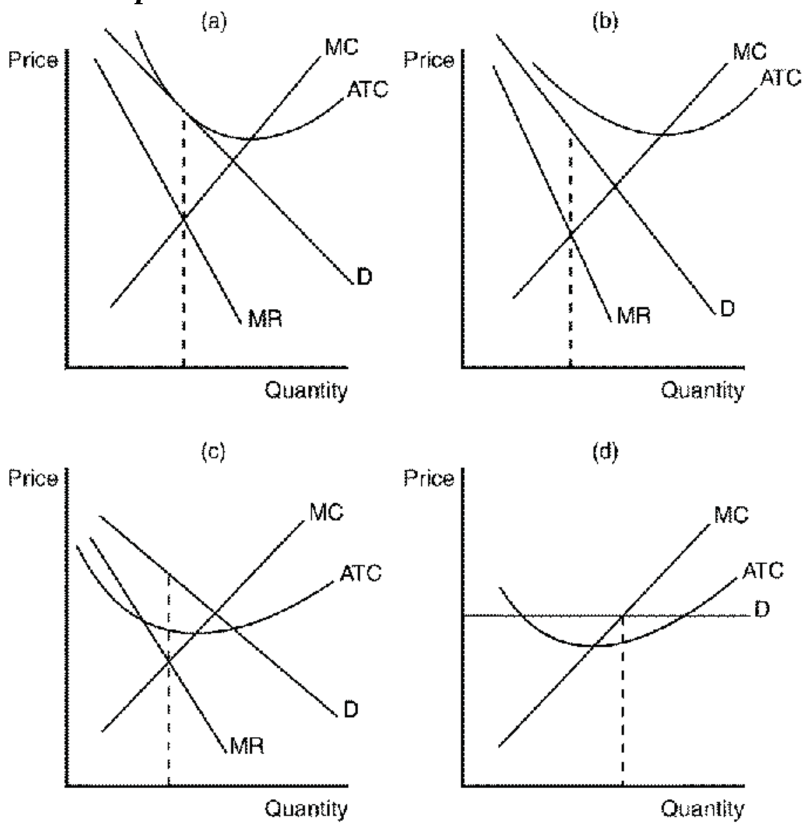
Table: Income Tax Rates for Single vs. Married

Rate	Single Income Ranges	Married Income Ranges
10%	$0 – $9,000	$0 – $18,000
15%	$9,000 – $36,000	$18,000 – $73,000
25%	$36,000 – $88,000	$73,000 – $146,000
28%	$88,000 – $183,000	$146,000 – $223,000
33%	$183,000 – $398,000	$223,000 – $398,000
35%	$398,000 - $400,000	$398,000 - $450,000
40%	over $400,000	over $450,000

22. ***Refer to Table: Income Tax Rates for Single vs. Married***. Mia and Matt have been dating for several years and they are thinking about getting married. They each make $150,000 per year. If they do get married, what is their "marriage penalty"? That is, how much more will they pay in taxes as a married couple than they would if they were both single?
a. There is no marriage penalty
b. $2,560
c. $4,650
d. $6,120

Name:_________________________ Class:______________ Date: _____________ ID: A

Figure: Monopolistic Competition



23. ***Refer to Figure: Monopolistic Competition.*** Which of the graphs depicts a short-run equilibrium that will encourage the entry of other firms into a monopolistically competitive industry?

a. Panel (a)
b. Panel (b)
c. Panel (c)
d. Panel (d)

Table: Game II.

		Firm 2		
		X	**Y**	**Z**
Firm 1	**A**	(4,4)	(2,2)	(7,3)
	B	(7,7)	(3,8)	(9,6)
	C	(3,5)	(4,6)	(8,4)

24. ***Refer to Table: Game II.*** How many pure strategy Nash equilibria exist in this game?
Difficulty 2/3

a. 0
b. 2
c. 3
d. 1

Table: Oligopoly. The information in the table below shows the total demand for premium-channel digital cable TV subscriptions in a small urban market. Assume that each cable operator pays a fixed cost of $200,000 (per year) to provide premium digital channels in the market area and that the marginal cost of providing the premium channel service to a household is zero.

Quantity	**Price (per year)**
0	$180
3,000	$150
6,000	$120
9,000	$ 90
12,000	$ 60
15,000	$ 30
18,000	$ 0

25. ***Refer to Table: Oligopoly.*** Assume there are two digital cable TV companies operating in this market. If they are able to collude on the quantity of subscriptions that will be sold and on the price that will be charged for subscriptions, then their agreement will stipulate that

a. each firm will charge a price of $60 and each firm will sell 6,000 subscriptions.
b. each firm will charge a price of $90 and each firm will sell 4,500 subscriptions.
c. each firm will charge a price of $120 and each firm will sell 3,000 subscriptions.
d. each firm will charge a price of $150 and each firm will sell 1,500 subscriptions.

26. ***Refer to Table: Oligopoly.*** Assume there are two profit-maximizing digital cable TV companies operating in this market. Further assume that they are not able to collude on the price and quantity of premium digital channel subscriptions to sell. What price will premium digital channel cable TV subscriptions be sold at when this market reaches a Nash equilibrium under Cournot (quantity) competition?

a. $30
b. $60
c. $90
d. $120

Table: Tax Systems

	Tax A	***Tax B***	***Tax C***
Income	***Tax Rate***	***Tax Rate***	***Tax Rate***
$0 - $50,000	***30%***	***25%***	***20%***
$50,000 - $100,000	***25%***	***25%***	***25%***
over $100,000	***20%***	***25%***	***30%***

27. ***Refer to Table: Tax Systems***. Which represents a proportional tax?

a. Tax A
b. Tax B
c. Tax C
d. None of the above

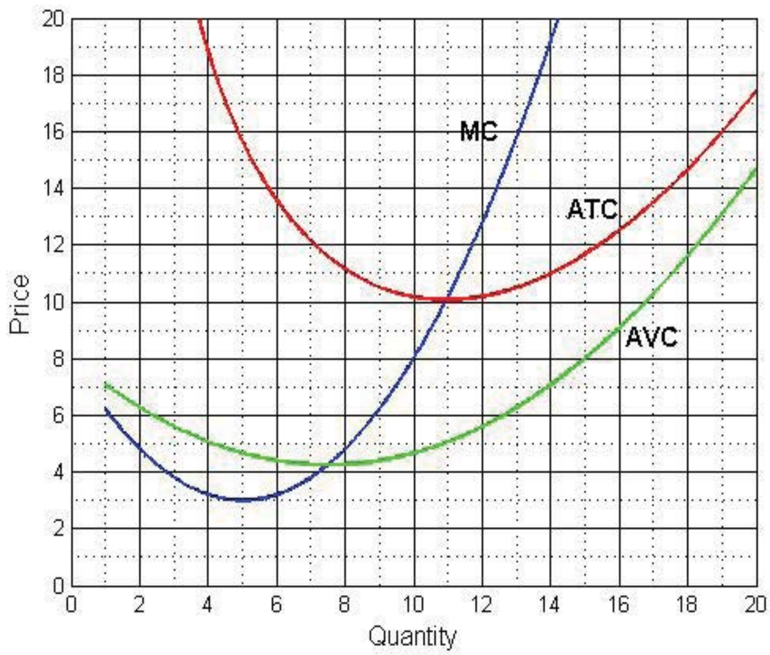
28. ***Refer to Table: Tax Systems***. Which represents a lump-sum tax?

a. Tax A
b. Tax B
c. Tax C
d. None of the above

Name:________________________ Class:_____________ Date: ____________ ID: A

29. Which of the following is NOT a barrier to entry that leads to the rise of monopoly power?
a. Annual rental contracts that cannot be broken.
b. Government grants an exclusive right to produce a good.
c. Declining ATC curve for all quantities.
d. Ownership of a key resource.

Figure: Perfect Competition II



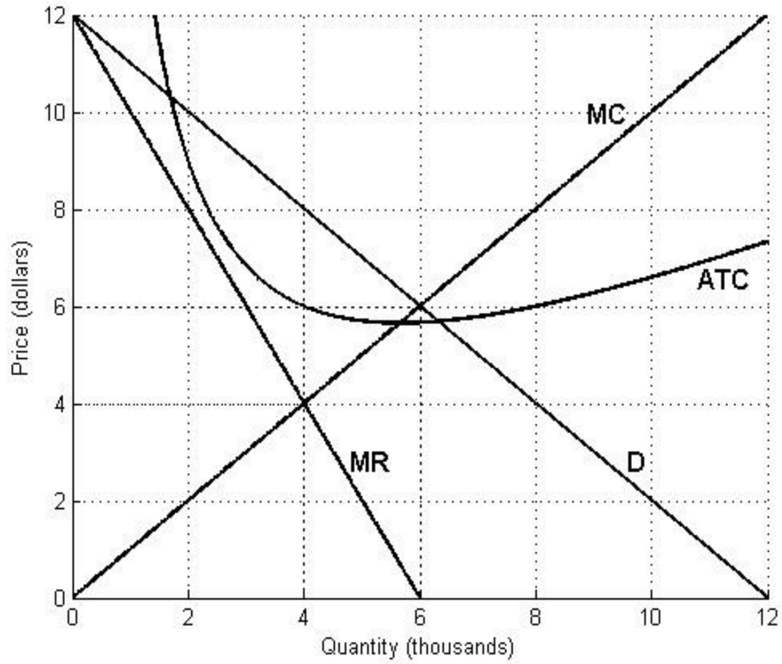
30. ***Refer to Figure: Perfect Competition II.*** What is this firm's shut-down price? **Difficulty 1/3**
a. $2.50
b. $10
c. $4.25
d. $8

31. ***Refer to Figure: Perfect Competition II.*** If this perfectly competitive firm faces a price of $19 per unit of its product, what is its total profit? **Difficulty 2/3**
a. $64
b. $112
c. $85
d. $168

32. ***Refer to Figure: Perfect Competition II.*** If the current market price is $8 and all other firms in the industry are identical to this one, what can we expect to happen in the long-run? **Difficulty 1/3**
a. Some firms will exit the industry, causing the equilibrium price to rise.
b. Some firms will exit the industry, causing the equilibrium price to fall.
c. Demand for the product will fall, causing the equilibrium price to fall.
d. Demand for the product will rise, causing the equilibrium price to rise.

Name:_________________________ Class:______________ Date: _____________ ID: A

Figure: Monopoly.



33. ***Refer to Figure: Monopoly.*** What is this monopolist's profit if it cannot price discriminate? **Difficulty 2/3**

a. $1,500
b. $8,000
c. $16,000
d. $36,000

Scenario: Cost. Suppose a firm's total costs are given by TC = 200 + 0.5(Q + Q^2), in dollars.

34. ***Refer to Scenario: Cost.*** What is the firm's marginal cost of the third unit of output (the correct answer below assumes you will use the discrete definition of marginal cost, if you use calculus choose the nearest answer).

a. $3
b. $6
c. $12
d. $206

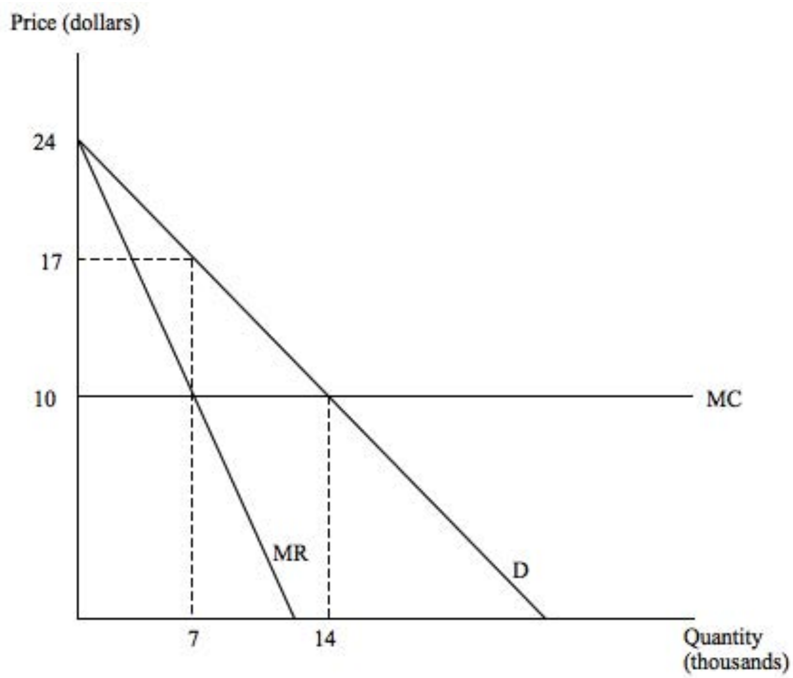
35. ***Refer Scenario: Cost.*** What is the fixed cost facing the firm?

a. $0.50
b. $50
c. $100
d. $200

36. What is a key difference between firms in a perfectly competitive versus a monopolistically competitive industry? **Difficulty 1/3**

a. Marginal cost pricing versus mark-up.
b. Efficient scale versus excess capacity.
c. Identical products versus slightly differentiated products.
d. All of the above.

Figure: Constant Marginal Cost



37. ***Refer Figure: Constant Marginal Cost.*** Suppose there are no fixed costs. What is the deadweight loss due to monopoly?

a. $20
b. $40
c. $24.50
d. $49

Scenario: Firm Costs. Suppose a firm has total cost curve $TC = 64 + 6Q + Q^2$ and marginal cost curve $MC = 6 + 2Q$.

38. ***Refer to Scenario: Firm Costs.*** If the firm is perfectly competitive, what is its exit price?

a. $18
b. $20
c. $22
d. $24

39. ***Refer to Scenario: Firm Costs.*** Suppose the costs above belong to a monopolist facing demand curve $P = 36 – 2Q$. What is the firm's profit-maximizing price?

a. $26
b. $31
c. $24
d. $29

40. ***Refer to Scenario: Firm Costs.*** Suppose the costs above belong to a monopolist facing demand curve $P = 36 – 2Q$. What is the firm's profit?

a. $13
b. $11
c. $9
d. $7

Name:__________________________ Class:______________ Date: _____________ ID: A

Final Exam, Fall 2013-14
Answer Section

Multiple Choice

1.	ANS: B	DIF: 2/3	Ref: Ch. 12
2.	ANS: A	DIF: 1/3	Ref: Ch. 12
3.	ANS: A	DIF: 2/3	Ref: Ch. 13
4.	ANS: C	DIF: 2/3	Ref: Ch. 13
5.	ANS: A	DIF: 1/3	Ref: Ch. 14
6.	ANS: C	DIF: 2/3	Ref: Ch. 14
7.	ANS: D	DIF: 1/3	Ref: Ch. 16
8.	ANS: A	DIF: 2/3	Ref: Ch. 17
9.	ANS: D	DIF: 2/3	Ref: Ch. 17
10.	ANS: B	DIF: 1/3	Ref: Ch. 9
11.	ANS: D	DIF: 2/3	Ref: Ch. 13
12.	ANS: B	DIF: 1/3	Ref: Ch. 14
13.	ANS: B	DIF: 2/3	Ref: Ch. 14
14.	ANS: A	DIF: 2/3	Ref: Ch. 14
15.	ANS: A	DIF: 2/3	Ref: Ch. 17
16.	ANS: D	DIF: 2/3	Ref: Ch. 17
17.	ANS: C	DIF: 1/3	Ref: Ch. 15
18.	ANS: B	DIF: 2/3	Ref: Ch. 17
19.	ANS: A	DIF: 2/3	Ref: Ch. 15
20.	ANS: C	DIF: 2/3	Ref: Ch. 13
21.	ANS: C	DIF: 2/3	Ref: Ch. 13
22.	ANS: C	DIF: 3/3	Ref: Ch. 12
23.	ANS: C	DIF: 1/3	Ref: Ch. 16
24.	ANS: D	DIF: 2/3	Ref: Ch. 17
25.	ANS: B	DIF: 3/3	Ref: Ch. 17
26.	ANS: B	DIF: 2/3	Ref: Ch. 17
27.	ANS: B	DIF: 1/3	Ref: Ch. 12
28.	ANS: D	DIF: 1/3	Ref: Ch. 12
29.	ANS: A	DIF: 1/3	Ref: Ch. 15
30.	ANS: C	DIF: 1/3	Ref: Ch. 14
31.	ANS: B	DIF: 2/3	Ref: Ch. 14
32.	ANS: A	DIF: 1/3	Ref: Ch. 14
33.	ANS: B	DIF: 2/3	Ref: Ch. 15
34.	ANS: A	DIF: 2/3	Ref: Ch. 13
35.	ANS: D	DIF: 1/3	Ref: Ch. 13
36.	ANS: D	DIF: 1/3	Ref: Ch. 16
37.	ANS: C	DIF: 2/3	Ref: Ch. 15
38.	ANS: C	DIF: 3/3	Ref: Ch. 14
39.	ANS: A	DIF: 3/3	Ref: Ch. 15
40.	ANS: B	DIF: 2/3	Ref: Ch. 15