Becoming More Student-Centered? An Examination of Faculty Teaching Practices across STEM and non-STEM Disciplines between 2004 and 2014

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Introduction

Several reports over the past few years have called for increases in the productivity of bachelor's degrees in science, technology, engineering, and mathematics (STEM) fields (National Research Council, 2012; President's Council of Advisors in Science and Technology, 2012). Although persistence and completion research generally and in STEM particularly have focused on individual characteristics, skills, and experiences (Seymour & Hewitt, 1997; Tinto, 1994), the research community has begun to shift its focus to the kinds of pedagogy students get exposed to in the classroom (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Moravec et al., 2010). Study after study has shown that students experience greater learning gains and demonstrate greater engagement in class when their instructors rely more heavily on learner-centered teaching techniques (Allen & Tanner, 2005; Bowen et al., 2012; Fulton, 2012; Gasiewski et al., 2012; Moravec et al., 2010). Such learner-centered techniques include small group discussions, question-and-answer time with faculty, hands-on activities in the classroom, and group projects, among others (Fairweather, 2008; Graham et al., 2013).

Data over the past 25 years show a shift toward increased use of student-centered teaching practices (Eagan, Stolzenberg, Berdan Lozano, Suchard, & Hurtado, 2014). Indeed, faculty in many disciplines have moved toward integrating more student-centered techniques into their courses, but faculty in STEM disciplines have lagged behind their colleagues in the social sciences, arts, humanities, and professional fields in making this change (Hurtado, Eagan, Pryor, Whang, & Tran, 2012). Hurtado et al. (2012) demonstrate that faculty in STEM fields relied upon student-centered teaching techniques significantly less often than their colleagues in the arts, humanities, social sciences, and professional fields. Instead, Hurtado et al. (2012) show that faculty teaching in STEM fields rely much more heavily on extensive lecturing and curve-based grading in their courses relative to their colleagues in non-STEM fields.

Although studies have shown a gap in the use of student-centered teaching practices between faculty in STEM fields and their colleagues in other disciplines, research has given less focus to differences in faculty teaching practices within the specific disciplines that comprise the broader STEM classification. This report aims to highlight differences in faculty's teaching practices across sub-disciplines within STEM and compare these findings to faculty in select non-STEM disciplines. The following sections provide additional information about the report's methodology, findings, and discussion of the results.

Methodology

This report draws upon data from the Higher Education Research Institute's (HERI) Faculty Survey. HERI began administering its triennial Faculty Survey in 1989. The comprehensive instrument touches upon all areas of faculty work, including teaching practices, research, service obligations, perceptions of campus climate, satisfaction, and demographic and employment information. For the past 10 years, the HERI Faculty Survey has been the only national survey of faculty at four-year institutions after the federal government discontinued its National Survey of Postsecondary Faculty (NSOPF) in 2004. This report specifically analyzes data from the past four Faculty Survey administrations: 2004-05, 2007-08, 2010-11, and 2013-14.

The analyses looked across these four administrations for eight faculty subgroups: biological sciences[1], physical sciences[2], engineering, computer science, mathematics, economics, social sciences excluding economics, and the arts and humanities. Excluded from this report are faculty who teach in the fields of education, business, and the health sciences. Table 1 provides unweighted counts for each of the disciplines represented in the analyses across the four administrations.

Table 1
Sample Sizes by Field and Year

	2004	2007	2010	2014
Biological Sciences	2,110	1,544	1,513	984
Physical Sciences	2,504	1,747	1,612	973
Engineering	970	678	637	393
Computer Science	412	380	511	268
Mathematics	1,902	1,054	1,126	668
Economics	278	333	391	209
Social Sciences	4,199	2,830	2,652	1,513
Arts and Humanities	12,435	7,765	7,716	4,269

The data from each administration of the HERI Faculty Survey are weighted within institutions by sex and rank; additionally, data are weighted within institutional stratification cells (control, type, and selectivity) by rank and sex (Eagan et al., 2014). With these statistical weights applied, the findings represent the national sample of full-time faculty who teach undergraduate students. The 2014 administration of the HERI Faculty Survey collected fewer responses across all disciplines due to a compressed survey administration period.

This report relies upon descriptive statistics to look at changes over time in faculty teaching practices. For six of the seven practices highlighted in this report, trends over time are shown for the years in which each item was asked. For all seven practices, data are also shown in stacked bar graphs to highlight the full distribution of the frequency with which faculty reported relying on each practice in 2014. The following section presents the findings from the analyses.

Findings

This section begins by highlighting trends for two instructor-centered practices: extensive lecturing and curve-based grading. The section then moves into the five student-centered practices agreed upon by HERI and the Sloan Foundation.

Faculty's use of lecture is unavoidable in most undergraduate classrooms, but extensive use of lecture encourages passive learning and limits time for students to fully engage with course content. Figure 1 shows the trends with which faculty relied upon extensive lecturing in *all* or *most* of their courses between 2004 and 2014. Overall, trends show a decline in faculty's use of extensive lecturing between 2004 and 2014. Generally, the figure shows that 80% of

[1] Biological science disciplines include biochemistry, biology, botany, genetics, microbiology, physiology, and zoology.
[2] Physical science disciplines include astronomy, atmospheric sciences, chemistry, geological and earth sciences, and physics.

faculty in many STEM disciplines (biological sciences, physical sciences, engineering, and mathematics) used extensive lecturing in *all* or *most* of their courses in 2004, and that percentage dropped to the high 60s and low 70s for these fields by 2014. Extensive lecturing among computer science faculty actually increased during this period, going from 62.2% in 2004 who used this method in *all* or *most* of their courses to 68.7% in 2014. Faculty in the social sciences and the arts and humanities experienced declines in their use of extensive lecturing through 2010 before experiencing an increase in use in 2014. Even with these increases, the data continue to show that more than two-thirds of faculty across STEM sub-fields utilize extensive lecturing in *all* or *most* of their courses in 2014 compared to 60.3% of faculty in the social sciences and 37.1% of faculty in the arts and humanities.

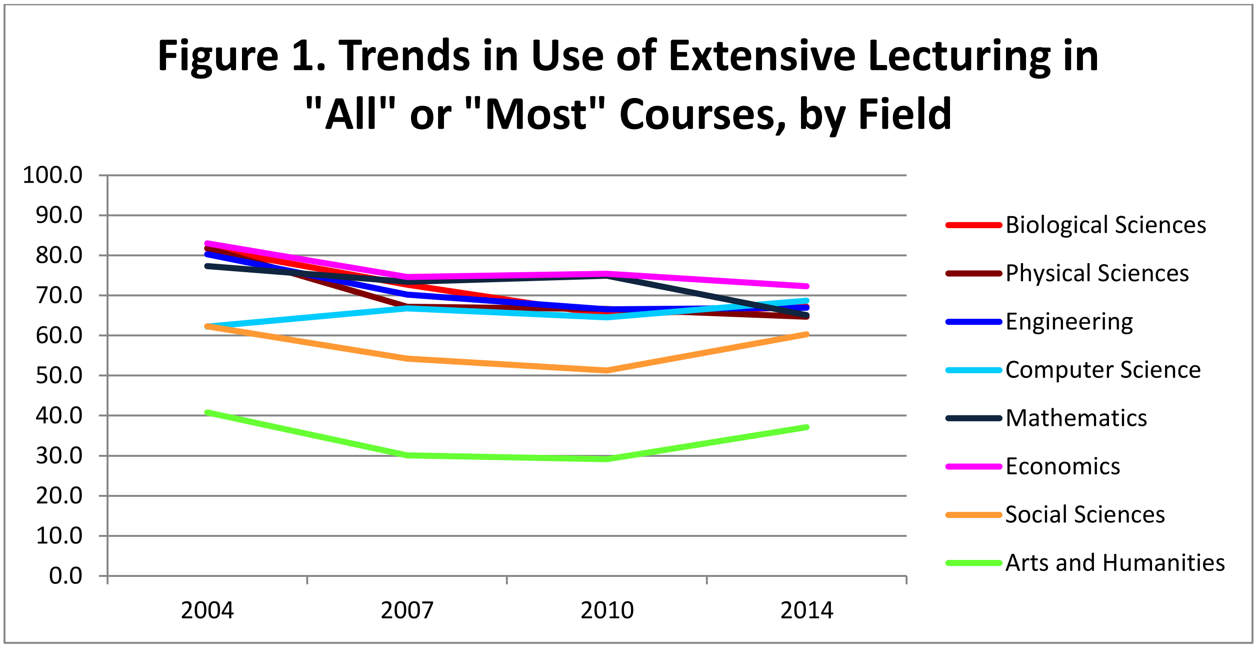
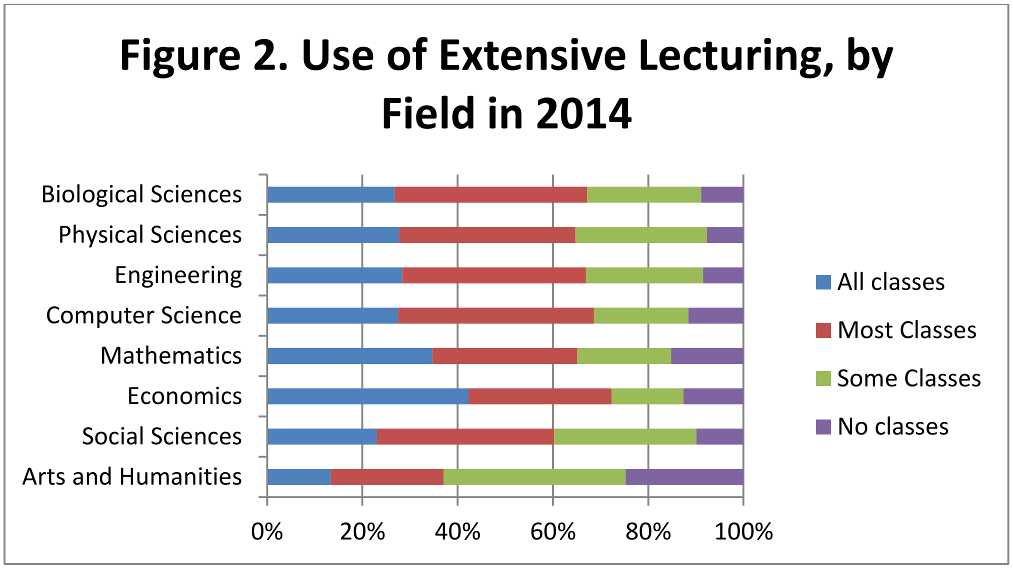
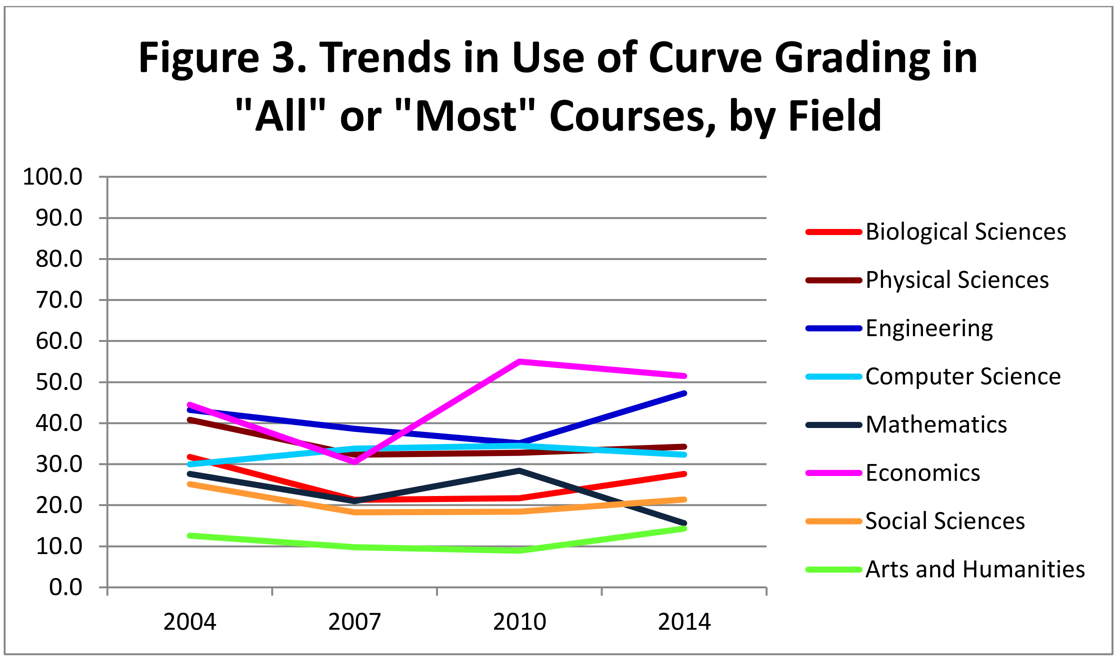


Figure 2 provides a more refined breakdown of faculty's use of extensive lecturing in 2014. Faculty in economics were the most likely to report using extensive lecturing in *all* or *most* of their courses (42.3%). About one-third (34.7%) of faculty in mathematics used extensive lecturing in *all* or *most* of their courses compared to 28.4% of faculty in engineering, 27.5% of faculty in computer science, 27.7% of faculty in the physical sciences, and more than one-quarter (26.8%) of faculty in the biological sciences. By contrast, 23.1% of social science faculty and 13.4% of faculty in the arts and humanities incorporated extensive lecturing in *all* or *most* of their courses in 2014.

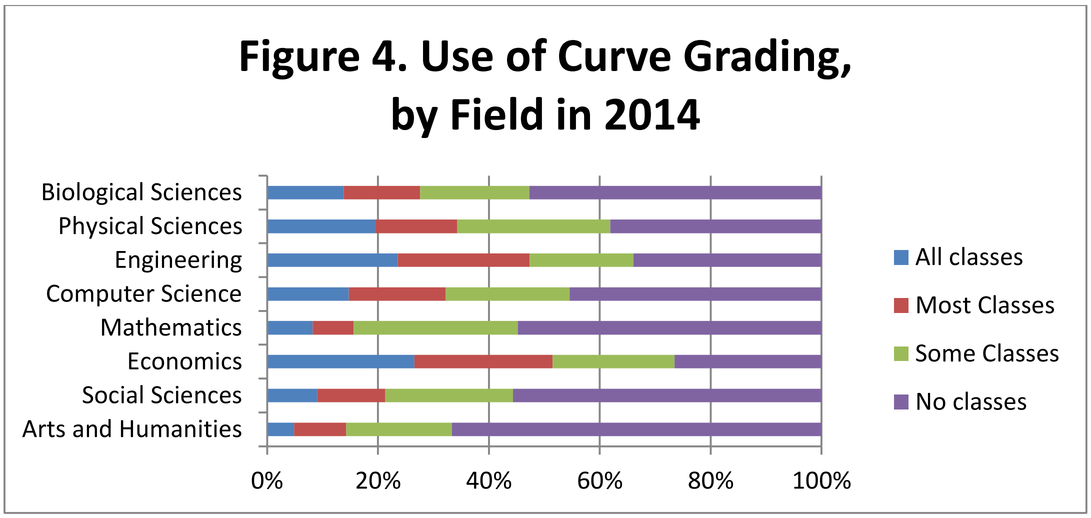




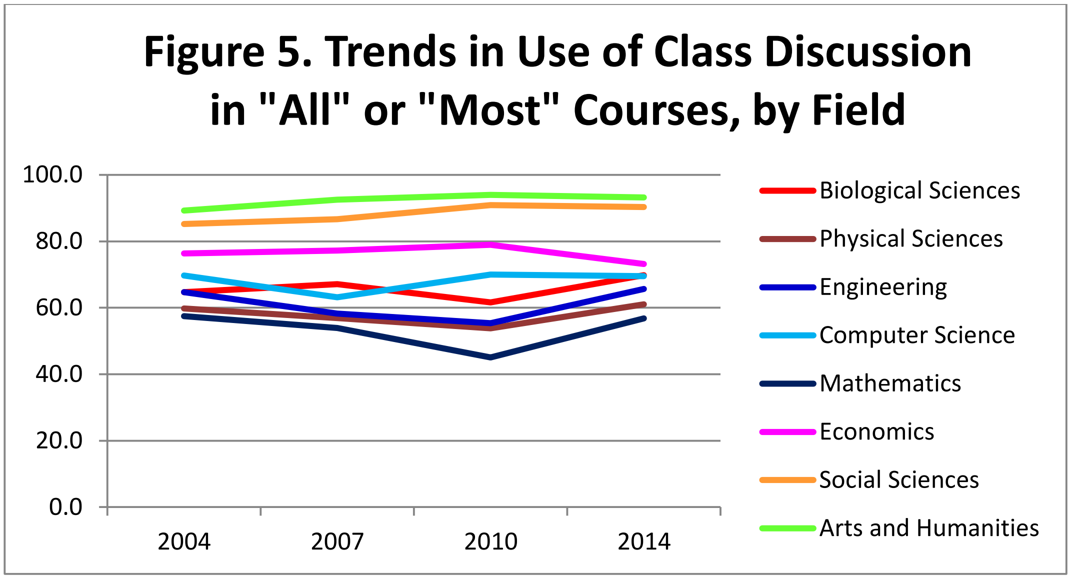
A second instructor-based method analyzed for this report regards faculty's grading practices. Hurtado et al. (2012) demonstrated that faculty in STEM rely more heavily on curve-based grading relative to their colleagues in other disciplines, and curve-based grading often increases students' sense of competition in the classroom and may discourage collaboration (Gasiewski et al., 2012). Figure 3 demonstrates the relative stability of this evaluation practice across most disciplines over the past decade. Faculty in economics rely upon this practice most often in their courses, with 44.5% indicating they utilized curve-based grading in *all* or *most* of their courses in 2004 increasing to more than half (51.5%) by 2014. Faculty in engineering also have increased their utilization of curve-based grading over the past 10 years, as 43.2% of engineering faculty did so in *all* or *most* of their courses in 2004 compared to 47.3% in 2014.

Mathematics faculty appear to have bucked the trend of stability or slight increases in use of curve-based grading. More than one-quarter (27.6%) of faculty in mathematics departments used this method regularly in 2004 compared to 15.6% by 2014. As with extensive lecturing, the data show that faculty in the arts and humanities rely on curve-based grading significantly less often than their colleagues in other fields.

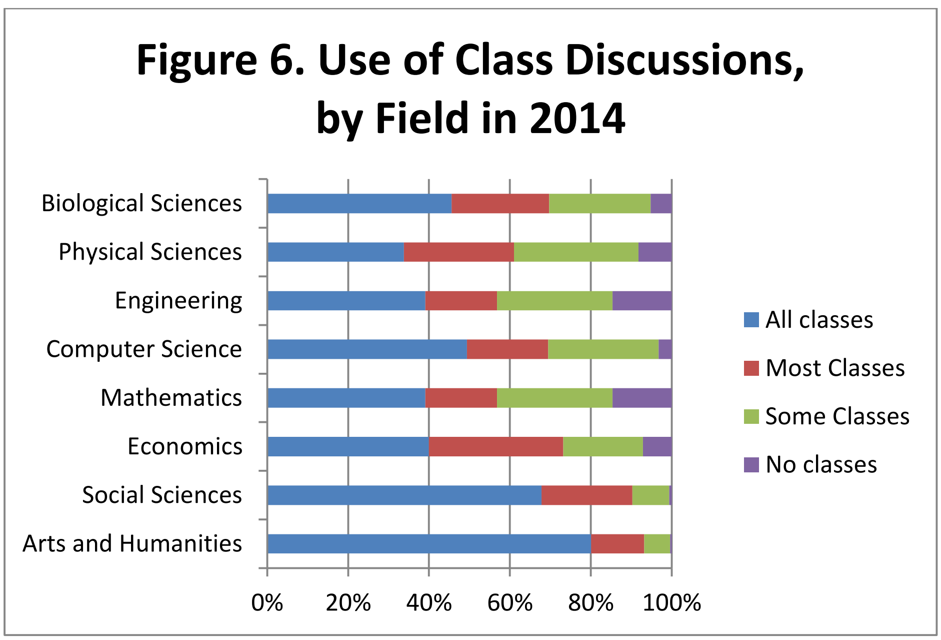
Findings in Figure 4 provide details on the full distribution of faculty's use of curve-based grading in 2014. More than one-quarter (26.6%) of economics faculty and nearly one-quarter of faculty in engineering (23.6%) used curve-based grading in *all* of their courses in 2014. Roughly one in five faculty in the physical sciences (19.5%) did the same. By contrast, fewer than one in 10 faculty in the social sciences (9.0%), mathematics (8.2%), and the arts and humanities (4.9%) relied upon curve-based grading in *all* of their courses in 2014.



The remainder of this section focuses on faculty's use of student-centered practices. Class discussions provide an opportunity for students to engage with each other and the instructor about course content, and Figure 5 highlights trends in faculty's use of this technique over the past decade. Use of class discussions in *all* or *most* courses has increased among faculty in the social sciences and their colleagues in the arts and humanities. Since 2010, more than 90% of faculty in these areas rely heavily on class discussions in their teaching. Faculty in economics and other STEM disciplines have remained relatively stable over the past decade in their use of class discussions, and a substantial gap persists between them and their colleagues in the social sciences and the arts and humanities. For the past 10 years, about three-quarters of economics faculty have reported using class discussions in *all* or *most* courses, and about 70% of computer science faculty have relatively consistently done the same. More faculty in the biological sciences have begun using class discussions in *all* or *most* of their courses in the past 10 years, going form 64.7% in 2004 to 69.8% by 2014. Class discussions are much less commonly used by mathematics faculty; 57.% used this technique in *all* or *most* courses in 2004, which was nearly identical to the 56.8% who reported doing so in 2014.



The findings regarding faculty in the arts and humanities and social sciences are even more impressive when we consider the full distribution of this measure in 2014, which is shown in Figure 6. About 80% of faculty in the arts and humanities and two-thirds (67.8%) of faculty in the social sciences reported using class discussions in *all* of their courses. About half (49.4%) of computer science faculty and 45.6% of faculty in the biological sciences reported doing the same. Roughly two in five faculty in the areas of economics (40%), mathematics (39.1%), and engineering (39.1%) utilized class discussions in *all* of their courses in 2014. Just about one-third of physical science (33.8%) incorporated class discussions in *all* of their courses in 2014.



As campuses have tried to keep pace with improving technology, faculty have had an opportunity to integrate more technology into their teaching. One way to provide students with information as to how well they have mastered certain concepts is through electronic quizzes, which can offer students instantaneous feedback as to what they know well and areas they may need to study further. This particular method has been on the HERI Faculty Survey since 2007, and Figure 7 provides the trend lines on faculty's adoption of this technique. The data show that faculty utilized this method incredibly infrequently in 2007, with computer science faculty (12.4%) indicating they used electronic quizzes in *all* or *most* of their courses. By contrast, faculty in the arts and humanities were the least likely to do so (3.0%). By 2014, roughly one-quarter of biological science (23.0%) and physical science (27.7%) faculty were using electronic quizzes in *all* or *most* of their courses, with 20.6% of computer science faculty doing the same. Roughly one in 10 of faculty in economics (10.2%), engineering, (10.2%), mathematics (10.9%), and social sciences (11.9%) used electronic quizzes in *all* or *most* of their courses.

Figure 7. Trends in Use of Electronic Quizzes with Immediate Feedback in "All" or "Most" Courses, by Field

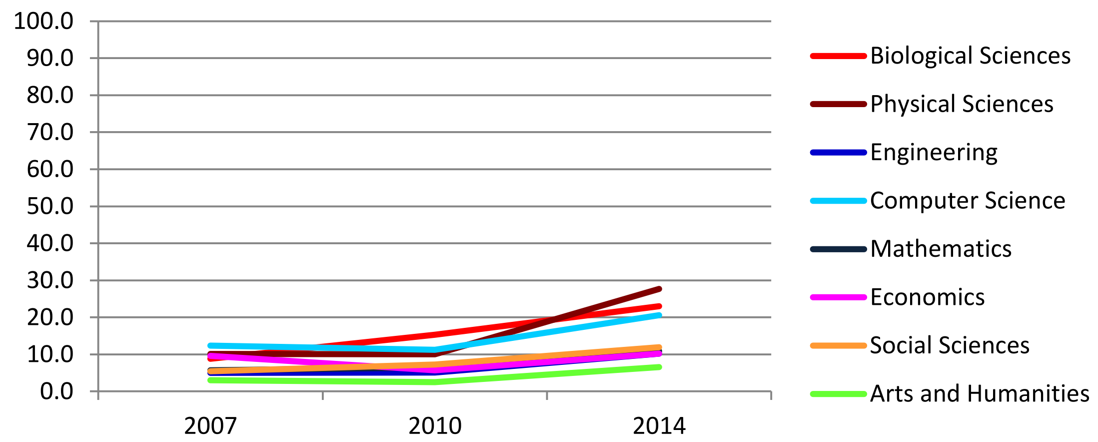
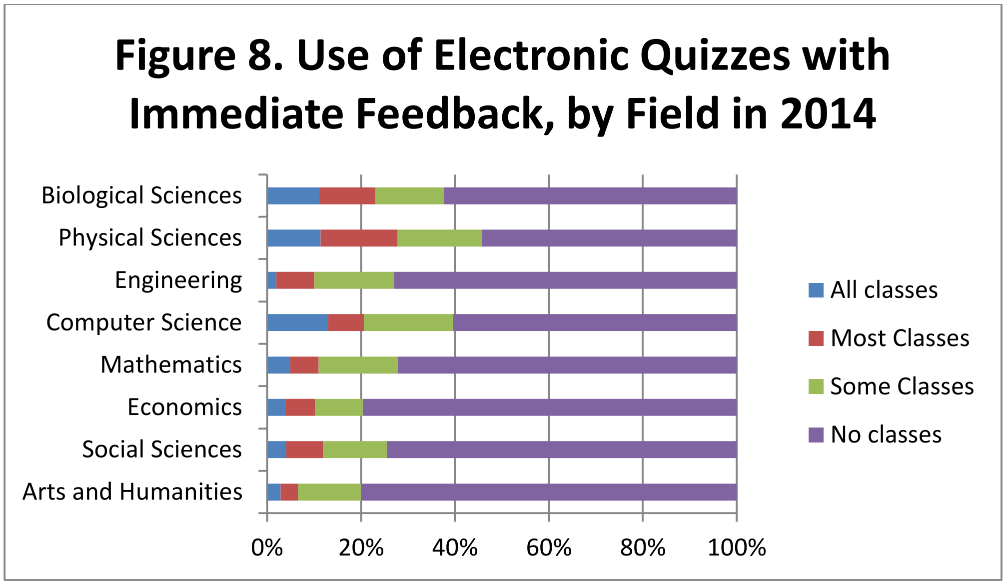
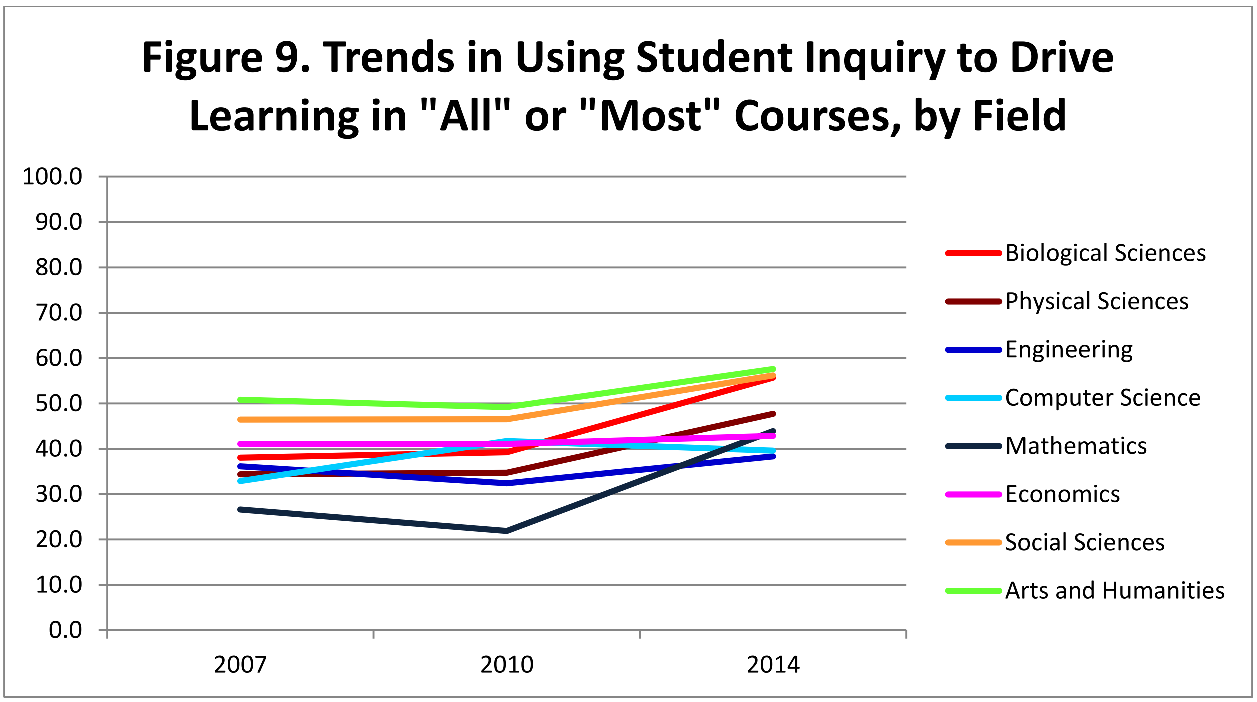
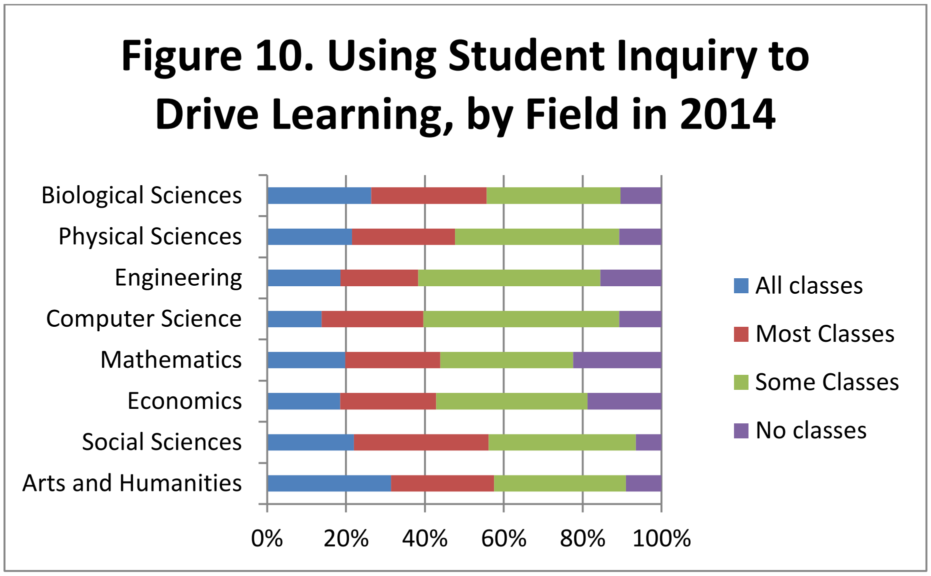


Figure 8 presents the full distribution of this item for the 2014 administration of the HERI Faculty Survey. More than one in 10 faculty in computer science (13.0%), physical sciences (11.4%), and biological sciences (11.1%) used electronic quizzes in *all* of their courses. Fewer than 5% of faculty in all other disciplines represented in the report did the same.

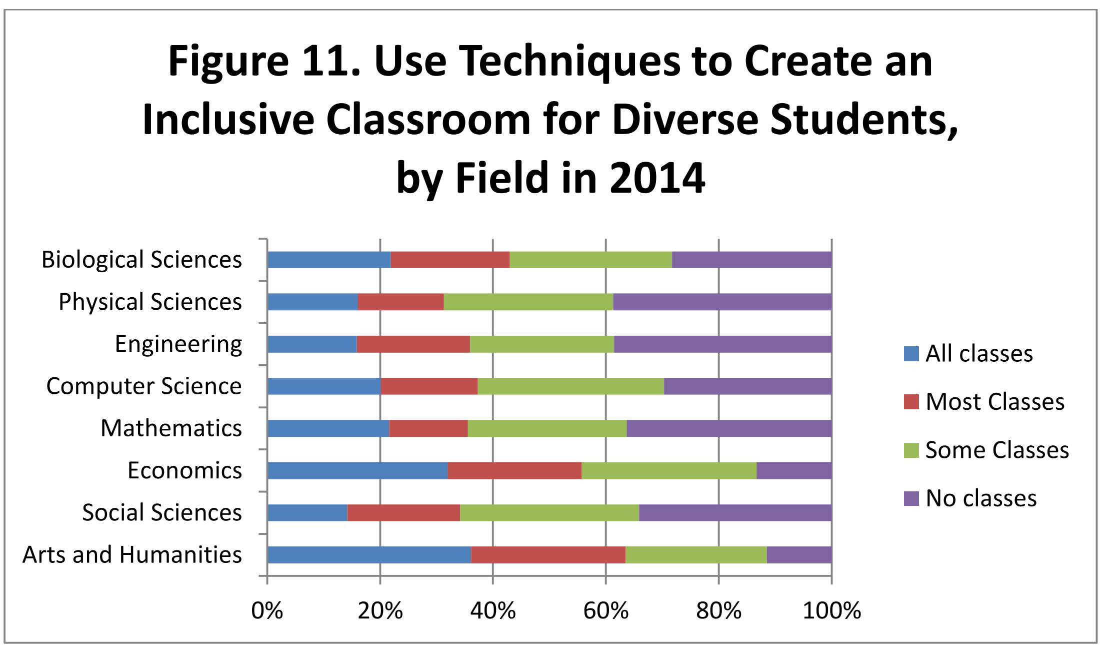




The next set of figures focus on faculty's use of student inquiry to drive learning, and this item has been included on the survey since 2007. Providing opportunities for students to engage in discovery and to ask questions that shape the path of the course offer increased chances of student engagement. As shown in Figure 9, since 2007 we have seen a slight increase in faculty's use of this technique across the board. Roughly half of faculty in the social sciences and the arts and humanities used student inquiry to drive learning in *all* or *most* of their courses in 2007, and those figures jumped to 56.2% and 57.6% by 2014. Faculty in the biological sciences experienced the most gains, moving from 38.0% in 2007 to 55.7% in 2014 using this technique in *all* or *most* of their courses. The proportion of mathematics faculty using student inquiry to drive learning doubled between 2010 and 2014, with 43.9% using the technique in *all* or *most* of their classes by 2014.



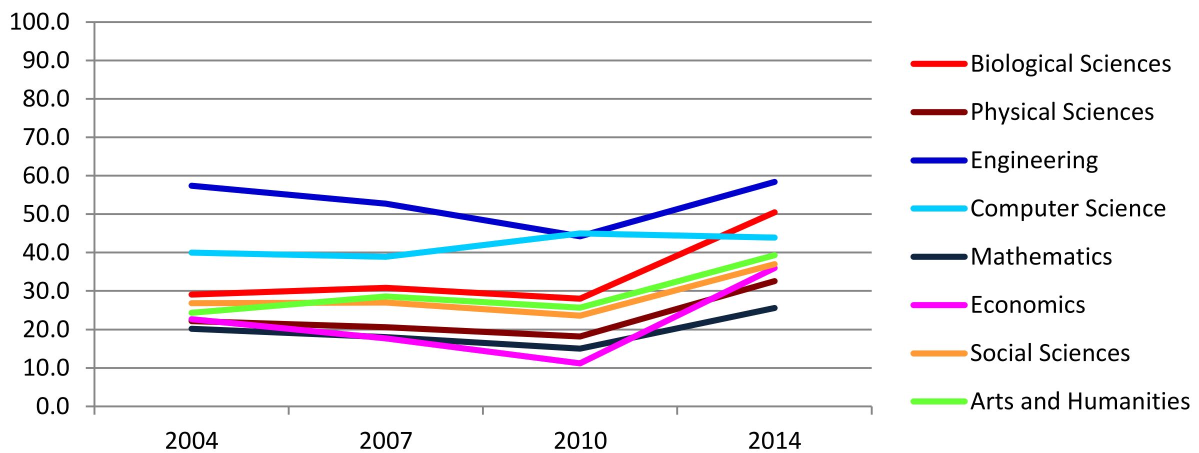
The breakdown of this item for the 2014 administration appears in Figure 10. Nearly one-third of arts and humanities faculty used student inquiry to drive learning in *all* of their courses in 2014, which was several percentage points above their colleagues in the biological sciences (26.4%), social sciences (22.0%), and physical sciences (21.5%). Roughly one in five faculty in mathematics (19.8%), engineering, (18.6%), and economics (18.5%) did the same. Computer science faculty were the least likely (13.8%) to use this technique in *all* of their courses in 2014.



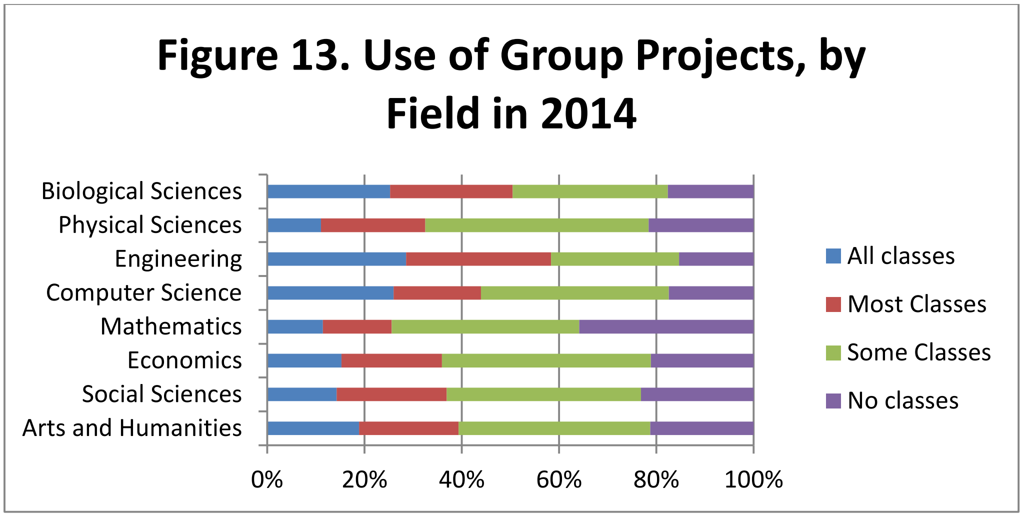
In 2014 an item about faculty's use of techniques to create inclusive classrooms for diverse students was added to the HERI Faculty Survey. Inclusive teaching practices are particularly important for students from diverse backgrounds so as to ensure they do not feel marginalized when trying to learn. Figure 11 provides the full breakdown of this item. More than one-third of faculty in the arts and sciences (36.1%) used these techniques in *all* of their courses, which exceed the figure for economics faculty (31.9%) by 4.2 percentage points. Roughly one in five faculty in the biological sciences (21.9%), mathematics (21.%), and computer science (20.1%) used inclusive classroom techniques in *all* of their courses in 2014. Just 16.0% of physical science faculty, 15.9% of faculty in engineering, and 14.2% of faculty in the social sciences did the same.

Perhaps more concerning is the proportion of faculty who reported not using these techniques in *any* of their courses. Nearly two in five faculty in the physical sciences (38.7%), engineering (38.6%), and mathematics (36.3%) reported not using inclusive techniques in any of their courses. Similarly, 34.1% of social science faculty, 29.7% of computer science faculty, and 28.3% of faculty in the biological sciences never incorporated inclusive teaching practices in their courses in 2014. About one in 10 (11.5%) of faculty in the arts and humanities said they never used inclusive teaching practices in any of their courses. Given goals of diversifying the STEM workforce, these findings make clear that more work in terms of faculty training and development needs to occur among faculty in STEM departments so they understand the necessity and value of such techniques and master these skills.

Figure 12. Trends in Use of Group Projects in "All" or "Most" Courses, by Field



The final practice analyzed for this report focused on faculty’s use of group projects. Group projects allow students to engage with one another, and oftentimes these projects offer opportunities for students to teach and learn from one another, providing peers with another chance to explain or master course concepts. Figure 12 shows that, on the whole, faculty’s incorporation of group projects in *all* or *most* of their courses appears to be increasing since 2004. Faculty in engineering are consistently among the most likely to utilize group projects in *all* or *most* classes. Nearly three in five engineering faculty reported doing so in 2004 (57.4%), which was nearly identical to the proportion who reported doing so in 2014 (58.4%). Two out of five computer science faculty used group projects in all or most of their courses in 2004 (40.0%) compared to 43.9% in 2014. Faculty in the biological sciences experienced the greatest gains in using this technique in *all* or *most* of their courses; 29.1% did so in 2004, and this figure jumped to more than half (50.5%) by 2014. Faculty in mathematics departments tended to incorporate group projects into their courses with less regularity than their colleagues in other disciplines; just 20.2% of math faculty did so in 2004 compared to about one-quarter (25.6%) in 2014.



Finally, Figure 13 shows the distribution of faculty's use of group projects in their classes for the 2014 administration. More than one-quarter of faculty in engineering (28.6%), computer science (26.0%), and the biological sciences (25.3%) incorporated group projects into *all* of their courses in 2014. By contrast, faculty in math (11.5%) and the physical sciences (11.1%) were the least likely to have group projects as part of *all* of their courses.

Conclusion

Findings from this report highlight the persistent gap between faculty in STEM fields and their colleges in the social sciences and the arts and humanities in using more student-centered teaching techniques. Faculty in several STEM fields have more quickly adopted electronic quizzes as part of a feedback mechanism to students compared to their colleagues in non-STEM disciplines, and engineering, computer science, and biological science faculty have incorporated group projects into their courses at higher rates compared to their counterparts in other departments. However, we still see a heavy reliance among STEM faculty broadly on extensive lecture and, to a lesser extent, on curve-based grading. Research continues to consistently show the benefits of moving toward a more inclusive, student-centered classroom, and faculty across all departments, but particularly in STEM disciplines, need to receive training and incentives necessary to promote their shift toward a more engaging classroom.

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