

The Effect of Plus-Minus Grades on Graduation With Academic Distinction for Engineering Students at Wichita State University

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Abstract

The effect of a plus-minus grade system on graduation with academic distinction at a medium-size public university was considered. Commencement program brochures were used to determine the number of *summa cum laude*, *magna cum laude*, and *cum laude* graduates over a five-year period when whole-letter grades were used and for a similar period under the plus-minus grade system. For the university as a whole, the number of *summa cum laudes* decreased with plus-minus grades while the number of graduates in the other distinction categories increased. However, in engineering, there was a decrease in *summa* and *magna cum laudes* without a corresponding increase in *cum laudes*. Actual grade distributions from individual classes were also considered to see how they relate to graduation with distinction.

Introduction

Grading at American universities has shown a trend of grade inflation over the last 50 years¹. Until 1965, a grade of C was the most common grade with a grade of A constituting less than 20% of all grades given from the 1940s through the mid-1960s. Rojstaczer and Healy¹ note that grade inflation began after that with a fairly significant rise in the number of A's and a corresponding drop in the number of C's. They speculate that this sudden grade inflation may have been a response by professors to the military draft during an unpopular war. Although grade inflation slowed somewhat during the 1970s and 1980s, A's constituted about 30% of all grades during that period. By the mid-1990s, a grade of A was the most common grade, and in 2008, A's constituted 43% of all grades.

The whole-letter grade system, which was prevalent during the rise of grade inflation, has been increasingly replaced by the plus-minus grade system since the 1990s. According to Brumfield², 36% of institutions used plus-minus grades in 1992, which increased to 56% by 2002 and to 63% by 2014³. In a study on student and faculty views about plus-minus grading, Morgan *et al.*⁴ mentions that a key motivator behind a change to plus-minus grade system is a "belief that [it] can either reverse the progression of grade inflation or counter its effects by establishing more grade choices so that performance can be more effectively differentiated."

Although publicly available grade information is not easily accessible, it is evident that nationwide grade inflation is also present at the authors' home institution of Wichita State University (WSU). During a Faculty Senate meeting in 2004, the University Registrar reported that the grade of A was the most prevalent grade at WSU.⁵ Over the next several years, the Faculty Senate commissioned a study on the use of a plus-minus grade system in lieu of the current whole-letter grade system and conducted a faculty survey on the issue. Advocates for the change focused on how the new grading system would provide a more accurate reflection of student performance. The proposal to change to a plus-minus grade system was ultimately approved by a single vote during the university's General Faculty Meeting,⁶ and the university transitioned to this new grading system during the 2009-2010 academic year. Since the implementation of the plus-minus grading system, many honors students have expressed concern that their grade point averages (GPAs) are lower because of plus-minus grading. Recently, the Student Government Association at WSU raised this issue with the Faculty Senate, arguing for elimination of plus-minus grading.⁷

Results reported in the literature varied in terms of the effect of plus-minus grading on student

GPA. According to Barnes and Buring⁸, no differences were found in the mean cumulative GPA when the University of Cincinnati College of Pharmacy transitioned from whole-letter grade to plus-minus grading scale. This contrasts with Bressette⁹ who suggested that there was a small reduction in GPAs which served to slow the rise in grade inflation based on results from several large universities as well as his own liberal arts college. In their report on studies at several universities, Fisher *et al.*¹⁰ found that student GPAs were not affected. They surmised that this was because the pluses cancelled the minuses over the course of a student's academic career. However, they recognized that there would be a "small deflationary effect" on students in the top A grade bracket. Based on studies at several different universities, Fries *et al.*¹¹ suggested that the effect of plus-minus grading may differ with discipline.

From an examination of these studies, two questions arise. First, how does a change to plus-minus grading affect top A-level students? Second, are there disciplinary differences, if any, from the effect of plus-minus grading? These two questions motivated the current study about the effect of a plus-minus grade system on graduation with academic distinction for engineering students.

Definition of Academic Distinction and Methodology

Since publicly available grade distribution information is not easily accessible, we investigated the effect of a plus-minus grade system by considering the number of graduates with academic distinction before and after the grading system change in the fall semester of 2009 at WSU. This serves as a proxy to cumulative student GPA, although the GPA ranges for the various levels of academic distinction are large. At WSU, graduation with *summa cum laude* distinction is awarded to students with a minimum GPA of 3.90, *magna cum laude* to students with a minimum GPA of 3.55, and *cum laude* to students with a minimum GPA of 3.25.¹² These GPA requirements have been the same since at least 1986, according to the first catalog available online. The GPA range for academic distinction varies from university to university,¹³ so results for academic distinction from the current study should not necessarily be correlated with those at other universities.

In order to determine the number of students graduating with academic distinction, commencement program brochures were examined from five-year periods before (fall 2002 through spring 2007) and after (spring 2014 through fall 2018) plus-minus grades were instituted. The spring semester of 2014 corresponded to five full academic years under the plus-minus grade system at WSU, which means that the vast majority of graduates in the second time period would have fallen under the plus-minus grade system while studying at WSU. Each brochure lists the discipline (i.e., college or degree type), student name, and academic distinction level of each graduate. The number of students graduating under each academic distinction level was counted for each discipline. Publicly available material was used for statistical purposes only, and individual student information was not collected as a part of this study.

It should be noted that academic distinction is awarded at WSU by meeting the GPA criteria for *both* the overall GPA, which includes transfer credit, as well as the GPA for credits taken at WSU. Although a whole-letter grade system is commonly used in Kansas community colleges, transfer students still have to meet the GPA criteria at WSU under the plus-minus grade system in order to graduate with academic distinction. For point of reference, 51% of the incoming students to WSU over the last ten years have been transfer students according to the Kansas Board of Regents¹⁴.

Grading Criteria and Other Changes Affecting GPA

Many instructors, including the first author whose data will be discussed later, converted the ten-point whole-letter grade scale into the plus-minus system as follows: the minus part of the grade for the lower 3 points, the whole letter for the middle 3 points, and the plus part for the upper 4 points. For example, a B- would be given for scores of 80 to 82.9, a B for scores of 83 to 85.9, and a B+ for scores of 86 to 89.9. However, grades of A+, F+, or F- were not awarded at WSU

under the new system.

The university has had a grade replacement policy since the mid 1990's whereby a student can retake a course up to three times, and the most recent grade counts as part of the GPA. Since this policy has remained in place during the two time periods under consideration, this policy affects both the whole-letter grade and plus-minus grade results in a similar manner. The authors are not aware of any changes to the university's probation policy. Although the university and the College of Engineering have increased retention efforts in recent years, the direct impact of this retention effort on the GPA of graduating seniors is not known and no attempts were made to quantify this effect.

University-wide Results of Graduation with Academic Distinction

During a five-year period before plus-minus grades were introduced, 4.2% of graduates (out of 9731 graduates) were awarded *summa cum laude* (SCL) distinction, 15.6% *magna cum laude* (MCL) distinction, and 19.0% *cum laude* (CL) distinction. These results are shown in the left-hand chart of Figure 1. Five years after the implementation of a plus-minus grade system, starting in spring 2014, 3.7% of graduates (out of 11,527 graduates) were awarded *summa cum laude*, 17.7% *magna cum laude* and 20.9% *cum laude*, as shown in the right-hand chart of Figure 1. There were 0.5% fewer *summa cum laudes* overall, corresponding to a 12% reduction. This result was not surprising since plus-minus grading would most likely dampen the overall GPA of the top students. Interestingly, there was an increase in the number of *magna cum laudes* and *cum laudes* by approximately 2% each. Thus, under a plus-minus grade system, more students overall graduated with academic distinction. Since the number of *summa cum laudes* decreased by 0.5%, it is logical that these students would graduate *magna cum laude*. However, the increase of *magna cum laudes* was 2%, which means that some *cum laudes* became *magna cum laudes*. There was insufficient information to determine whether this result was due primarily to a change to a plus-minus grade system, continued grade inflation, or a combination of the two.

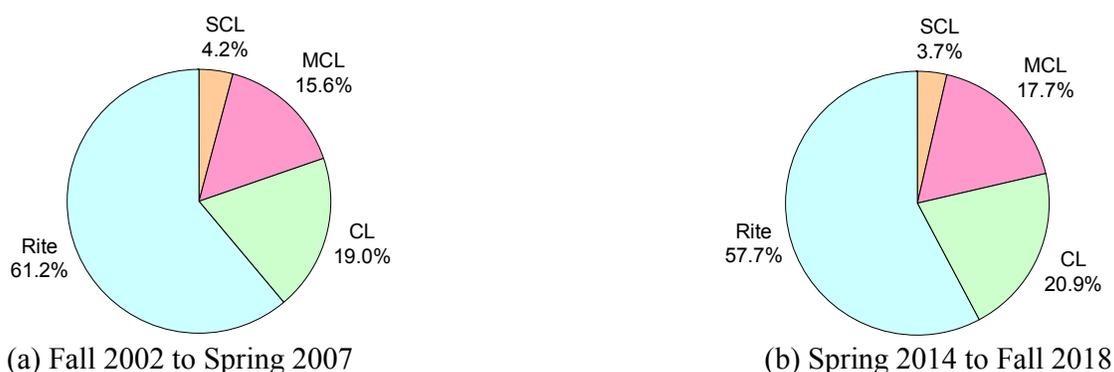


Figure 1 – Graduation with academic distinction. Key: *summa cum laude* (SCL in orange), *magna cum laude* (MCL in pink), *cum laude* (CL in green), and without distinction, referred to as *rite*, (blue).

University-wide Grade Distribution of Individual Classes under Whole-letter Grade System

One necessary point of reference is to see how grade distributions at WSU compare to nation-wide trends. Although publicly available grade distribution information is not easily accessible, the WSU Registrar released one semester's grade distribution along with student GPA achieved in the courses to the Faculty Senate during the early discussions about plus-minus grading. This information from the fall of 2003 is presented in Table 1. It should be noted that the sum of percentages associated with each grade, including W for withdrawal, did not total 100% for both the upper and lower division classes. The differences between the actual sums and 100% were 7% for lower division and 9% for upper division classes. Since the Registrar who provided this information more than 15 years ago is retired, it

is not possible to determine why the total was less than 100%. One possibility is that there were some students with incompletes. However, the authors' personal experience is that the number of incompletes has been typically less than that.

Table 1 – Grade distribution of course grades at WSU during fall of 2003, original data⁵

	W	F	D	C	B	A	GPA
Lower Division	11%	8%	5%	15%	23%	31%	2.78
Upper Division	7%	3%	3%	13%	27%	38%	3.12

In order to use this information, the distribution given in Table 1 was renormalized with the number of students who completed the course (i.e., grades of A-F) - 82% for lower division classes and 84% with upper division classes. The result of this renormalization is given in Table 2, which contains an additional row with the averages of percentages for the upper and lower division classes for each letter grade. Figure 2 graphically depicts the result of this renormalization with the addition of the national grade distribution provided in reference 1. Both Table 2 and Figure 2 show that the grade distribution at WSU is similar to national trends.

Several observations can be made from the results shown in Table 2 and Figure 2. First, there are more A's and B's and less D's and F's in upper division classes than lower division classes. Accordingly, the average GPA of 3.12 in upper division classes is higher compared to the average GPA of 2.78 in lower division classes. This difference suggests that the performance of students may have improved by the time they take upper division classes, which is not unexpected as students adjust to college. However, the increase in average GPA in upper division classes could also be attributed to the fact that underperforming students do not continue into upper division classes due to low grades.

Table 2 – Grade distribution of course grades at WSU during fall of 2003, renormalized

	F	D	C	B	A	GPA
Lower Division	9.8%	6.1%	18.3%	28%	37.8%	2.78
Upper Division	3.6%	3.6%	15.5%	32.1%	45.2%	3.12
Average	6.7%	4.8%	15.5%	30.1%	41.5%	2.95

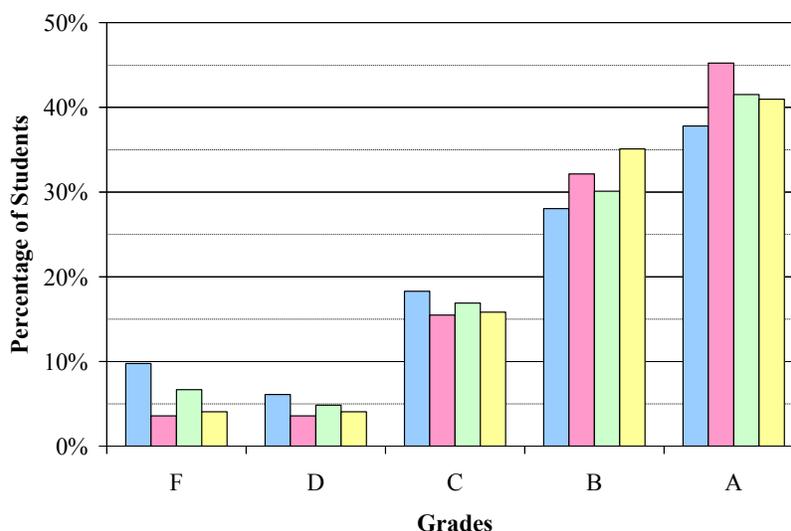


Figure 2 – Grade distribution of course grades at WSU from Table 2 for lower division (blue), upper division (pink), and average of two (green) plus nationally¹ (yellow), all in 2003.

Another observation is that the grade distribution does not follow a normal Gaussian distribution with a bell-shaped curve. The distribution is not symmetric with a peak in the middle of the

distribution and having similar-length tails to the left and right. Furthermore, in the case of the lower division class grade distribution, the tail on the left does not diminish, but increases to 9.8% F's compared to 6.1% D's.

Comparison of Score and Grade Distribution in Actual Engineering Courses

The grade distribution under plus-minus grading was not available university-wide; therefore, actual scores earned in classes and the resulting letter grades were obtained from a single instructor teaching sophomore and junior year engineering courses for the purposes of comparison between the two grading systems. Since the data is from a single instructor, instructor-to-instructor variation was eliminated. Five courses were selected in order to mimic, to a limited degree, variations in coursework for engineering students, particularly those in aerospace engineering. The dataset consists of 2020 students total from a first semester sophomore core course taken by all engineering students, two second semester sophomore foundation courses taken by aerospace and mechanical engineering students, and two specialty aerospace engineering courses taken in the first and second semesters of the junior year, both of which must be completed before the capstone design course in the senior year. Sections taught from spring 2002 to summer 2009 under the whole-letter grade system and from fall 2009 to spring 2014 under plus-minus grading were used in the comparison.

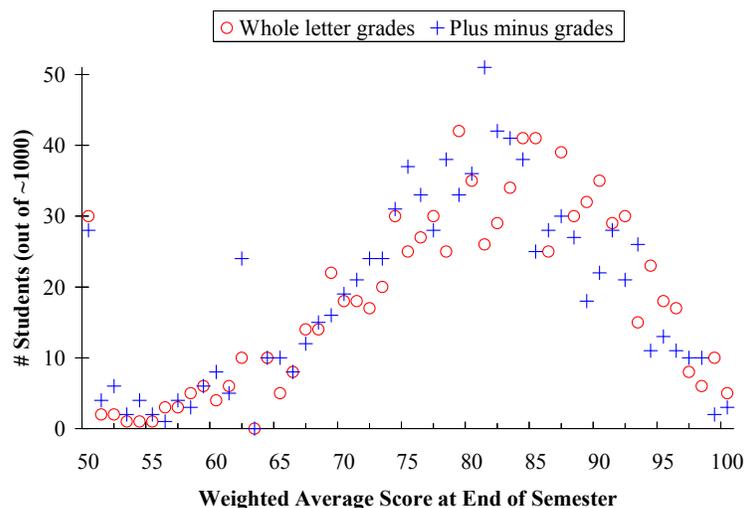


Figure 3 – Score distribution for sophomore and junior year aerospace engineering courses under the whole-letter grade system and the plus-minus grade system.

Figure 3 presents the score distribution for the courses under the two grading systems. The vertical scale represents the number of students that received a particular score, where the range of scores on the horizontal scale is from 50 to 100 in 1-point increments. Scores below 50 and those above 100 (if curving put the score above 100) were depicted as single data points at those respective limits. The circle symbol represents data for students under the whole-letter grade system, and the plus symbol represents data for students under the plus-minus grade system. The actual score distribution is not smooth and contains a large amount of scatter even with a dataset of 1000 students. The grades earned by students in the dataset of Figure 3 were also determined. Figure 4 shows the percentage of students that would receive a particular grade under each system with the data shown as plus symbols for each plus-minus grade. The whole-letter grade system data, shown as circle symbols, was separated into plus-minus grade bins based on the actual scores of the students.

Table 3 provides statistics on the sophomore and junior year classes, including the average student score and standard deviation, as well as the average GPA. It should be mentioned that about 70 students withdrew before the end of the course from each group so their scores and grades are not

included in the statistics. Particularly noticeable is the lower average score of the sophomore year group during the 2009-14 years, which is three points less than the average score of 79 for the 2002-09 years. The GPAs given in Table 3 indicate that the fall 2009 to spring 2014 classes have lower GPAs by $\sim 0.2 - 0.25$ grade points. Upon closer inspection of Figure 4, it is apparent that fewer A's and B's were earned from fall 2009 to spring 2014. This difference in the distribution of scores between the two time periods is reflected in the difference in GPAs.

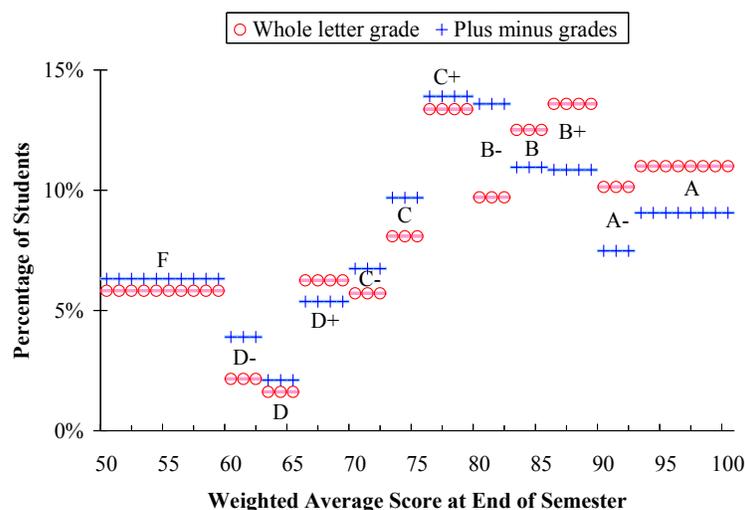


Figure 4 – Grade distribution for sophomore and junior year aerospace engineering courses under the whole-letter grade system and the plus-minus grade system.

Table 3 – Statistics associated with actual aerospace engineering course score and grade distribution

# students	# per class	Ave & σ	Actual GPA	← 2002-09 2009-14 → (whole letter) (+/-)	Actual GPA	Ave & σ	# per class	# students
471	36	79 \pm 17	2.51	Sophomore Year	2.23	76 \pm 15	47	471
529	44	80 \pm 13	2.85	Junior Year	2.68	81 \pm 11	61	549
1000	40	80 \pm 14	2.70	Overall Average	2.48	79 \pm 13	54	1020

If the scores received in fall 2009 through spring 2014 were converted to whole-letter grades, the GPAs under the whole-letter grade system would be 2.22, 2.69, and 2.48 for the sophomore, junior, and overall average, respectively, which is almost the same as the GPAs under the plus-minus grade system. This lack of difference in the GPAs between the two grade systems suggests that the difference in student performance possibly is due to a different factor. The College of Engineering at WSU has recently increased its enrollment. However, faculty hiring lagged behind growing enrollment, which resulted in larger class sizes. The average class size in the sophomore and junior year courses was 36 and 44, respectively during the spring 2002 to summer 2009 semesters. In comparison, the average class size was 47 and 61, respectively, during the fall 2009 to spring 2014 semesters. It is not surprising that student performance was affected as a result of increased class size. Recent increases in faculty numbers in the College of Engineering have begun to address this issue of large class size.

Effect of Plus-Minus Grades on Graduation with Academic Distinction By Discipline

The effect of the plus-minus grade system on graduation with academic distinction was also examined with respect to the different disciplines. Figure 5 presents the results for graduation with academic distinction by discipline with the left-hand side of each discipline showing the whole-letter grade system results (2002-07) while the right-hand side shows the results for the plus-minus grade

system (2014-18). Here, *summa cum laude* (SCL) is shown in orange, *magna cum laude* (MCL) in pink, and *cum laude* (CL) in green. It should be noted that comparisons between disciplines is not meaningful because of differences in graduation requirements, including varying GPA requirements or sophomore reviews for continuation in some programs, which are not present in other programs.

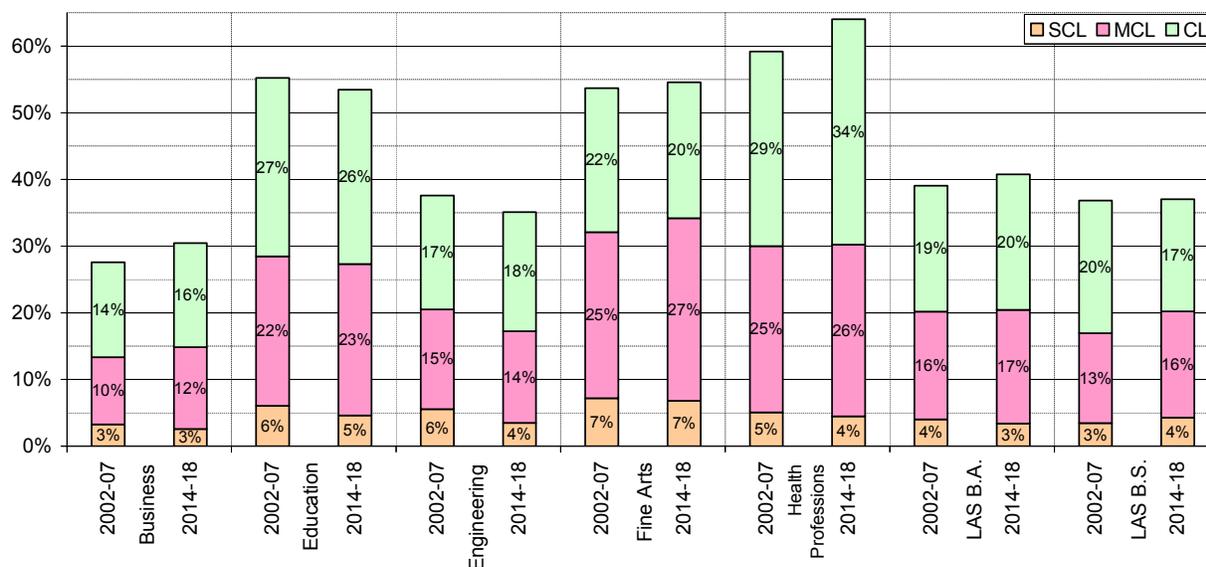


Figure 5 – Graduation with academic distinction by discipline under the whole-letter grade system (left) and under the plus-minus grade system (right).

Table 4 compares the difference in the percentage of students graduating with academic distinction by discipline under the two different grading systems. Data is shown for the individual academic distinction levels as well as the overall change to the percentage of students graduating with academic distinction. When the number of *summa cum laudes* (SCL) is considered, most disciplines have reduced percentages, including the College of Engineering, which experienced a reduction from 5.6% under the whole-letter grade system to 3.5% under the plus-minus grade system. The number of *magna cum laudes* (MCL) has increased by more than the reduction in *summa cum laudes* with the exception of the College of Engineering. It is possible that some students who might have graduated *cum laude* (CL) under the whole-letter grade system performed better. However, there is insufficient information to determine whether students' performance improved, grade inflation had continued, or a combination of the two occurred.

Table 4 – Difference in the percentage of students graduating with academic distinction by discipline under the two different grading systems

Discipline	SCL*	MCL*	CL*	CL+MCL+SCL
Business	-0.7%	+2.2%	+1.4%	+2.9%
Education (new name: Applied Studies)	-1.5%	+0.3%	-0.6%	-1.8%
Engineering	-2.1%	-1.2%	+0.8%	-2.9%
Fine Arts	-0.4%	+2.5%	-1.2%	+0.9%
Health Professions	-0.6%	+0.9%	+4.6%	+4.9%
Liberal Arts B.A.	-0.6%	+0.9%	+1.4%	+1.7%
Liberal Arts B.S.	+0.8%	+2.4%	-3.0%	+0.2%
Entire university	-0.5%	+2.1%	+1.9%	+3.5%

*Calculated by subtracting the left-hand value in Figure 5 from the right-hand value.

The bottom row of Table 4 examines the change in the percentage of graduates with academic

distinction university-wide. Under the plus-minus grade system, the overall percentage of *cum laudes*, *magna cum laudes*, and *summa cum laudes* has increased by 3.5%. The level of change in the percentage of graduates with academic distinction varying by discipline is consistent with the results mentioned by Fries *et al.*¹¹.

Among the various disciplines, the percentage of students graduating with academic distinction has increased with the exception of the Colleges of Engineering and Education. Stuart Rojstaczer,¹⁵ who has collected and analyzed grade and GPA data from over 160 colleges and universities, mentions that GPA differences exist between the disciplines with the lowest cumulative GPAs occurring for students in the natural sciences. However, our analysis for WSU shown in Figure 5 suggests that graduating with academic distinction is most difficult for business majors, which are not mentioned in Rojstaczer's study, closely followed by engineering.

Rojstaczer makes one additional interesting observation - that graduating with academic distinction at some schools requires a very high GPA, especially if the school determines academic distinction based on class ranking or percentile. This is due to grade compression, where most students typically receive an A in their coursework. If a school does not apply class rank as a criterion, then it may lead to a large fraction of the graduating class receiving academic distinction as mentioned by a recent Wall Street Journal article.¹⁶

Summary and Future Work

The effect of a plus-minus grade system on graduation with academic distinction at a medium-size public university was considered. Commencement program brochures were used to determine the number of *summa cum laude*, *magna cum laude*, and *cum laude* graduates over a five-year period when whole-letter grades were used and for a similar period under the plus-minus grade system. For the university as a whole, the number of *summa cum laudes* decreased with plus-minus grades while the number of graduates in the other distinction categories increased. However, in engineering, there was a decrease in *summa* and *magna cum laudes* without a corresponding increase in *cum laudes*. Actual grade distributions from individual classes were also considered, but the largest effect appeared to be due to class size rather than from a change to plus-minus grading. Future work could include administration of a survey about student perceptions on the plus-minus grade system from honors students as well as to see if there are changes due to grade inflation, if any, long term.

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