Is High School GPA a useful tool for identifying at-risk students in First-Year Engineering?

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Abstract

The First-Year Engineering Program (FEP) supports the retention and graduation goals for the College of Engineering with the primary goal of improving freshman-to-sophomore retention. We continually collect and analyze data in hopes of identifying effective methods for predicting students' academic success in engineering. This research is an effort to map out the relationship between incoming high school GPA and first semester GPA for our student cohort that attended FEP from 2007 to 2018. We considered the differences between in-state students and out-of-state students in their first fall semester academic performance.

We are particularly interested in students who struggled academically in their first semester. We know that one of the key indicators of students leaving engineering after their first semester is low GPA. Considering data collected from 2007 to 2018, 15% of students achieved a semester GPA below 2.0. High school GPA was only an adequate predictor of first fall academic success for students with high school GPA less than 3.0 (of which half the students ended up on probation) and for students with high school GPA greater than 4.0 (of which 98% ended their first semester with GPA 2.0 or above.)

Taking into consideration where a student went to high school, along with their high school GPA was a better and more useful predictor of fall academic success. From our data, we observed that students who have a predicted first fall GPA (predicted GPA based on student's high school GPA and considers where student attended high school) less than 3.0 were most likely to struggle academically in the first semester. We did not find statistical differences in first semester performance of students from in-state versus out-of-state.

Our goal is to use these results to identify incoming freshman students who may need additional support during their time with FEP. This will help us continue developing intervention programs that will promote increased retention rates for these students. One way to support these students will be with enhanced advising during summer orientation. We would consider the possibility of modified course schedules for their first semester to lessen the intensity of the rigorous curriculum in engineering eight-semester degree plans.

Introduction

Which students are most likely to experience success in college? The literature suggests that standardized test scores, high school GPA or a combination of the two may be used to predict student success in college to some degree [1, 2]. In addition to these cognitive variables, studies also focus on noncognitive factors that affect student success such as academic motivation and institutional integration [2,3]. While standardized test scores are uniformly administered to all students under similar conditions, they only measure a students' current knowledge base. Many studies have shown that success in high school academics (i.e. GPA) is a better indicator of success in college academics because it indicates students' intellectual habits; i.e. work ethic [4-

7]. However, high school GPAs may not be comparable across schools because they are based on grading criteria from different teachers in different schools with varying curricula and district standards.

College-level academic advising begins with new student orientation during the summer prior to the student's first-year. During this time, students, with the guidance of an advisor, must decide how to balance the demands of the rigorous engineering course work with the progress toward degree. For example, is putting a first-year student in calculus, physics, chemistry, composition and an elective (as the eight-semester degree plan expects) setting some students up for failure? Is it better to delay a science course to allow time to adjust to the dynamics of college life while at the same time potentially creating an even more difficult spring schedule or the need to take classes in the summer?

The purpose of this paper is to explore the success of first-year engineering students at the University of Arkansas by mapping out the relationship between incoming high school GPA and first semester GPA for our student cohort that attended First-Year Engineering Program (FEP) from 2007 to 2018. We pay special attention to students who struggled academically in their first semester and look for any indicators from their high school GPA that may have suggested the student was less likely to be successful academically. In addition, we consider the Estimated Fall 1 GPA data provided by the Graduation and Retention office and examine if this can help us to better identify the at-risk students.

Our goal is to use the information obtained from this analysis to identify incoming freshman students who may need specialized advising and additional support during their time with FEP. We will also support these students at the very beginning of their journey with us by enhanced advising during summer orientation to discuss the possibility of modified course schedules for their first semester to lessen the intensity of the rigorous curriculum suggested in engineering eight-semester degree plans. This study will help us continue developing intervention programs that will promote increased retention rates for students.

Research Questions

1) How does high school GPA compare to the first fall semester GPA for students enrolled in the College of Engineering at the University?
2) Can a student's high school GPA and high school attended be used to estimate a student's first fall semester GPA?
3) Are there differences in first fall semester GPA for in-state and out-of-state students enrolled in the College of Engineering at the University?

University Studied

University of Arkansas is a land grant, public university currently serving 23,025 undergraduate students. Minimum admission requirements for new freshman applicants is a high school GPA of 3.0 or higher on a 4.0 scale, and an ACT score of 20 or higher, or the SAT equivalent. As a

land grant university, University of Arkansas does not have separate entrance standards to the College of Engineering.

As of Fall 2019, the College of Engineering has 3,344 undergraduate students of which 24% is female. Underrepresented students (including female, minority and first-generation students) make up 51% of the first-year class. The first-year average ACT ranged from 27.8-28.8 and the first-year mean high school GPA ranged from 3.72-3.84 from fall 2015 to fall 2019. First-year retention rates in the College of engineering ranged from 67%-71% over the past five years and six year graduation rates ranged from 46%-50% over the same time frame.

At the University of Arkansas First-Year Engineering Program, we prepare our students, regardless of their incoming academic background, for the problem-solving requirements associated with second-year College of Engineering coursework, while also providing special opportunities to select Honors College students. Students receive modern and pedagogically sound instruction in general engineering courses while at the same time completing two semesters of calculus, one semester of chemistry and one semester of physics. Students who are not calculus-ready have the option to take a general engineering course that provides modern and pedagogically sound instruction over key topics from algebra, pre-calculus, and calculus in the context of engineering examples.

Methods

The University collects and retains admissions data (high school GPA, ACT/SAT score, high school attended, demographics, etc.) for all incoming students. The data analyzed in this study was limited to the freshman cohort from 2007-2018. Table 1 shows a summary of all the acronyms used through the rest of the paper.

Table 1: Acronyms used in Methods and Results and Discussion

Acronym	Explanation
HS GPA	High school Grade Point Average
Est FA1 GPA	Estimated first fall semester GPA
FA1 GPA	First fall semester GPA
SP1 GPA	First spring semester GPA
SP1 Cum GPA	Cumulative GPA at the end of first spring semester
FA2 GPA	Second fall semester GPA
FA2 Cum GPA	Cumulative GPA at the end of second fall semester
GPA*	Notation used to describe GPA ranges that are used both for HS GPA and for Est FA1 GPA in Figure 2.

We first looked at the relationship between HS GPA and FA1 GPA. For this analysis, students were broken down into the following FA1 GPA groupings:
- FA1 GPA < 2.0 – probation criteria,
- $2.0 \leq$ FA1 GPA < 3.0 – minimum progress toward degree criteria,
- $3.0 \leq$ FA1 GPA < 3.5 – common scholarship renewal criteria,

- FA1 GPA ≥ 3.5 – Honors College criteria.

We then considered both HS GPA and Est FA1 GPA when evaluating the success of students in their first fall courses. Est FA1 GPAs is a new metric that was recently developed by the University Graduation and Retention Office as a tool to help identifying at-risk students. Est FA1 GPAs are used to describe what a given student's high school GPA means at the University; this is based on the historical relation between HS GPAs and University GPAs of students from the same high schools. The Est FA1 GPAs are a prediction of student's FA1 GPA based on three factors: 1) the student's high school attended, 2) the student's HS GPA, and 3) a model regressing first-term University GPAs of past freshman from the same high school on those students' HS GPAs. Once the regression model is developed, student's HS GPA and the regression equation is used to calculate the Est FA1 GPA.

We modified the HS GPA and FA1 GPA ranges slightly when analyzing the results that include Est FA1 GPAs, because we needed to focus more on certain groups of students. We used the same ranges for both HS GPA and Est FA1 GPA for this part of the study; we will use the notation GPA* to represent these ranges since using just HS GPA, or just Est FA1 GPA, or a combination of these two notations might cause confusion. The ranges used are:
- GPA* < 2.5
- 2.5 ≤ GPA* < 3.0
- 3.0 ≤ GPA* < 3.5
- GPA* ≥ 3.5

For each of these four ranges, we noted the sample size and plotted the percentage of students in their specific FA1 GPA distributions. When choosing the ranges for FA1 GPA distributions, we chose the lower limit of HS GPA and above, the same range as HS GPA, one-band lower than the HS GPA (for example, if the HS GPA range is 2.5 – 3, we also looked at range 2.0 – 3.0 for FA1 GPA), and FA1 GPA lower than 2.0 to identify students on probation.

Lastly, we compared student success in the first fall semester between in-state (n=4740), out-of-state (n=2765), and international (n=233) students by statistically comparing FA1 GPA. A two-sample t-test assuming unequal variances was performed to determine if there was a significant difference between the FA1 GPA earned between each student grouping. We used an alpha of 0.05 for all analyses.

Results and Discussion

The overall statistics of HS GPA, Est FA1 GPA, FA1 GPA, SP1 GPA, SP1 Cum GPA, FA2 GPA and FA2 Cum GPA for all students in the cohort from 2007-2018 are presented in Table 2. The average HS GPA was 3.76 (n=7807) while FA1 GPA averaged 2.89. The difference between the sample sizes for FA1 GPA and FA2 GPA is 2715 students. 814 of these students are from the 2018 cohort, and we do not have the FA2 GPA on record for these students. The remaining 1901 students (24.4%) either left the college of engineering or the University of Arkansas before the beginning of their second semester. It is interesting to note that the Est FA1 GPA aligns very well with Fall 2 Cumulative GPA statistics.

Table 2. Sample size, means, median and standard deviation of high school GPA (HS GPA), estimated first fall semester GPA (Est FA1 GPA), first fall semester GPA (FA1 GPA), first spring semester GPA (SP1 GPA), cumulative GPA of first fall and spring GPAs (SP1 Cum GPA), second fall semester GPA (FA2 GPA) and cumulative GPA of first fall, first spring and second fall semester GPAs (FA2 Cum GPA) for all students in the cohort from 2007-2018.

	HS GPA	Est FA1 GPA	FA1 GPA	SP1 GPA	SP1 Cum GPA	FA2 GPA	FA2 Cum GPA
Sample size	7807	7707	7807	7018	7018	5092	5092
Mean	3.76	3.10	2.89	2.98	3.03	2.86	3.10
Median	3.82	3.19	3.09	3.20	3.18	3.00	3.17
StDev	0.41	0.55	1.02	0.96	0.82	0.97	0.66

High School GPA

As expected based on the literature, students with low HS GPAs (i.e., <3.0) had lower FA1 GPAs compared to students with HS GPAs that were >3.0 (Figure 1). Considering only the 373 students with HS GPA <3.0, 183 of them (53.4%) were on probation, which means they achieved a GPA below 2.0, after their first fall semester. Only 50 of them (13.4%) achieved a GPA of 3.0 or above.
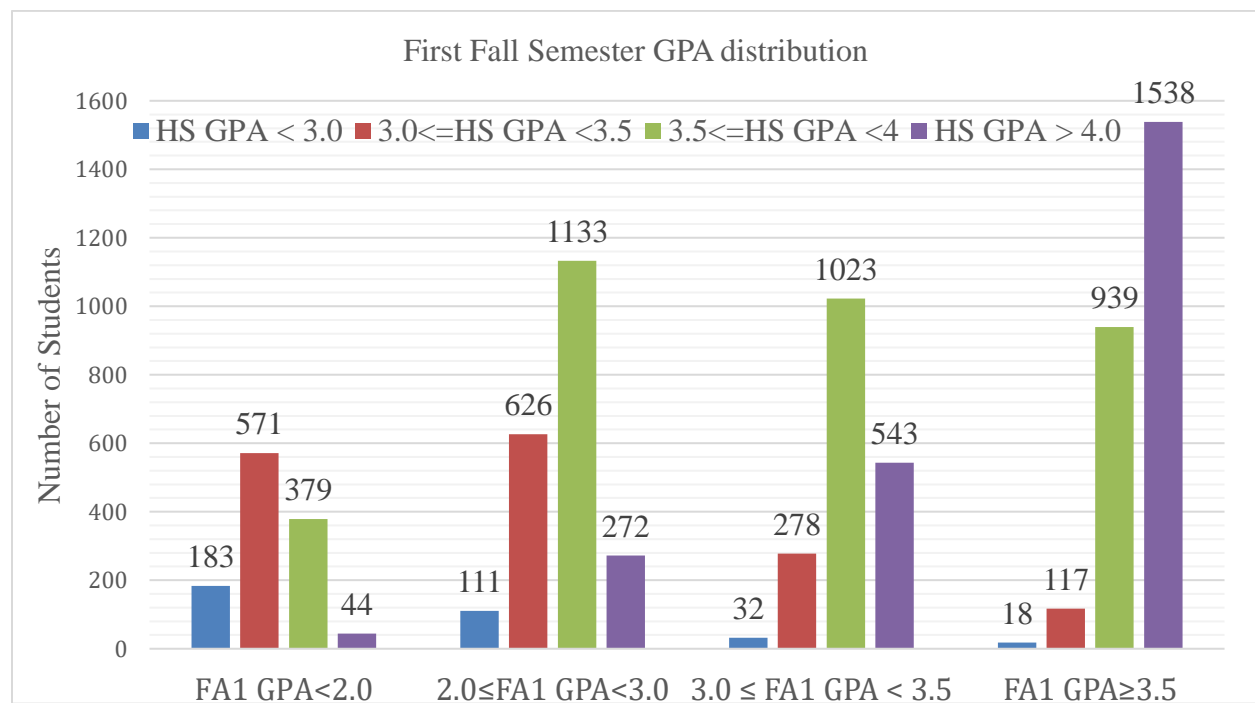

Figure 1. Distribution of First Fall Semester GPA (FA1 GPA) compared to High School GPA (HS GPA).

Students with HS GPAs >4.0 did well during FA1; out of 2397 students, 2353 of them (98.2%) achieved a FA1 GPA of >2.0 and 2081 of them (86.8%) achieved a GPA of 3.0 or above. Students with high school GPAs falling between 3.0 and 4.0 were variable in their FA1 GPA (Figure 1). 571 (38.3%) students with HS GPAs in 3.0 - 3.5 range and 379 (10.9%) students with HS GPAs in 3.5 – 4.0 range were on probation after their first semester.

Another way of analyzing the data was to categorize by the first Fall semester GPA ranges (Table 3). This helped us to see the HS GPA distribution of students that achieved a specific Fall 1 GPA.

Table 3. First Fall Semester GPA (FA1 GPA) broken down by High School GPA (HS GPA) Ranges.

FA1 GPA Range	# of Students in each FA1 GPA Range	HS GPA range	Number of Students in each HS GPA Range	Percent of Students in each HS GPA Range
FA1 GPA < 2.0	1177 (15.1%)	HS GPA < 3.0	183	15.5%
		3.0<=HS GPA <3.5	571	48.5%
		3.5<=HS GPA <4	379	32.2%
		HS GPA > 4.0	44	3.7%
2.0 ≤ FA1 GPA < 3.0	2142 (27.4%)	HS GPA < 3.0	111	5.2%
		3.0<=HS GPA <3.5	626	29.2%
		3.5<=HS GPA <4	1133	52.9%
		HS GPA > 4.0	272	12.7%
3.0 ≤ FA1 GPA < 3.5	1876 (24.0%)	HS GPA < 3.0	32	1.7%
		3.0<=HS GPA <3.5	278	14.8%
		3.5<=HS GPA <4	1023	54.5%
		HS GPA > 4.0	543	28.9%
FA1 GPA ≥ 3.5	2612 (33.5%)	HS GPA < 3.0	18	0.7%
		3.0<=HS GPA <3.5	117	4.5%
		3.5<=HS GPA <4	939	35.9%
		HS GPA > 4.0	1538	58.9%

According to the results in Table 3, 15.1% of the students in the data set were on probation at the end of first semester. Nearly half of these students had HS GPAs ranging from 3.0 to 3.5. Only 4.5% of this same group of students finished their first semester with a GPA of 3.5 or greater. These statistics show us that we should focus on this group in addition to the ones with HS GPA below 3.0 while developing modified advising and intervention plans. It is more difficult to differentiate the students who might be at-risk in the HS GPA range of 3.5 – 4.0. A considerable percentage of students (32.2%) on probation had HS GPAs in the 3.5 – 4.0 range. But, when we look at the higher FA1 GPA ranges, we see that some students who had HS GPAs in 3.5 – 4.0 range also did well; 1023 of them finished with a FA1 GPA between 3.0 and 3.5, and 939 of them finished with a FA1 GPA between 3.5 and 4.0.

While we know that the students with HS GPAs less than 3.5 need special attention and the students with HS GPAs above 4.0 most likely will do well, we need a better way to distinguish between the at-risk and not at-risk students in the middle HS GPA ranges. Considering the estimated first fall semester GPA data provided by the University Graduation and Retention Office might help to identify the at-risk students in this GPA range.

Estimated First Fall Semester GPA

Figure 2 shows comparison of HS GPAs and Est FA1 GPAs in the ranges described in the methods section. Since we use the same range for both HS GPA and Est FA1 GPA, we represented the GPA values in these ranges with the notation GPA* in the chart titles. These graphs help to visualize what percent of students with incoming HS GPA and Est FA1 GPA earn a first semester fall GPA in the specific range. We also provided the number of students with HS GPAs and Est FA1 GPAs in the given GPA* ranges with n_{HSGPA} and $n_{EstFA1GPA}$, respectively. Note that the Est FA1 GPAs are distributed over the ranges a lot more evenly than the HS GPAs. For example, there are only 24 students with HS GPAs below 2.5 whereas there are 1162 students with Est FA1 GPAs below 2.5. This is understandable since Est FA1 GPAs are a prediction of first fall semester GPAs that can range between 0 and 4.0, whereas the reported high school GPAs are rarely below 2.5 and go as high as 5.0. In fact, the lowest Est FA1 GPA in the data set is 1.5 and the highest is 4.0. The lowest HS GPA in the data set is 1.77 and the highest is 4.97.

For students with GPA* less than 2.5: Out of 1162 students who started with an Est FA1 GPA less than 2.5, 71.9% finished first fall semester with GPA less than 2.5 and 50.4% finished on probation. For the HS GPAs, the corresponding percentages are 66.7% and 45.8%. The Est FA1 GPAs and raw HS GPAs are both good at predicting that these set of students are at risk.

For students with GPA* 2.5 – 3.0 range: Out of 1687 students who started with Est FA1 GPAs in 2.5 – 3.0 range, 24.8% finished first fall semester with GPA in 2.5 – 3.0 range. For the HS GPAs, the corresponding number of students and percentage are 320 and 12.8%, respectively. This shows that although Est FA1 GPA is a better predictor, it still is not an efficient way of predicting the exact range of a student's FA1 GPA. However, if we look at the rest of the data on the same graph, we can conclude that it is a much better predictor than HS GPA for extended ranges and probation. For this group of students that have GPAs in 2.5 – 3.0 range, 22.2% of them with Est FA1 GPAs in this range ended up on probation, whereas 53.8% with HS GPAs ended up on probation. We can identify the students at risk of probation more successfully looking at the Est FA1 GPA range. Also, 58.6% of the students with Est FA1 GPAs in this range ended the semester with GPAs 2.5 and above, whereas only 26.9% of the students with HS GPAs ended the semester with GPAs 2.5 and above.

For students with GPA* in 3.0 – 3.5 range: Conclusions are similar to the previous HS GPA range; Est FA1 GPA is a better predictor of students who might end up on probation, and it is also a better indicator of the students' first fall semester GPAs, especially if we extend the range to one lower band than trying to predict an exact range. Here are some numbers to support this discussion. Out of 2931 students who started with Est FA1 GPAs 3.0 – 3.5 range, 33.1% finished first fall semester with GPA 3.0 – 3.5 range. For the HS GPAs, the corresponding number of students and percentage are 1592 and 17.5%, respectively. Also, 66.7% of the students with Est FA1 GPAs in this range ended the semester with GPAs 3.0 and above, whereas only 24.8% of the students with HS GPAs ended the semester with GPAs 3.0 and above. The results for probation is more significant. For this group of students, 6% with Est FA1 GPAs in this range ended up on probation, whereas 35.9% with HS GPAs ended up on probation.
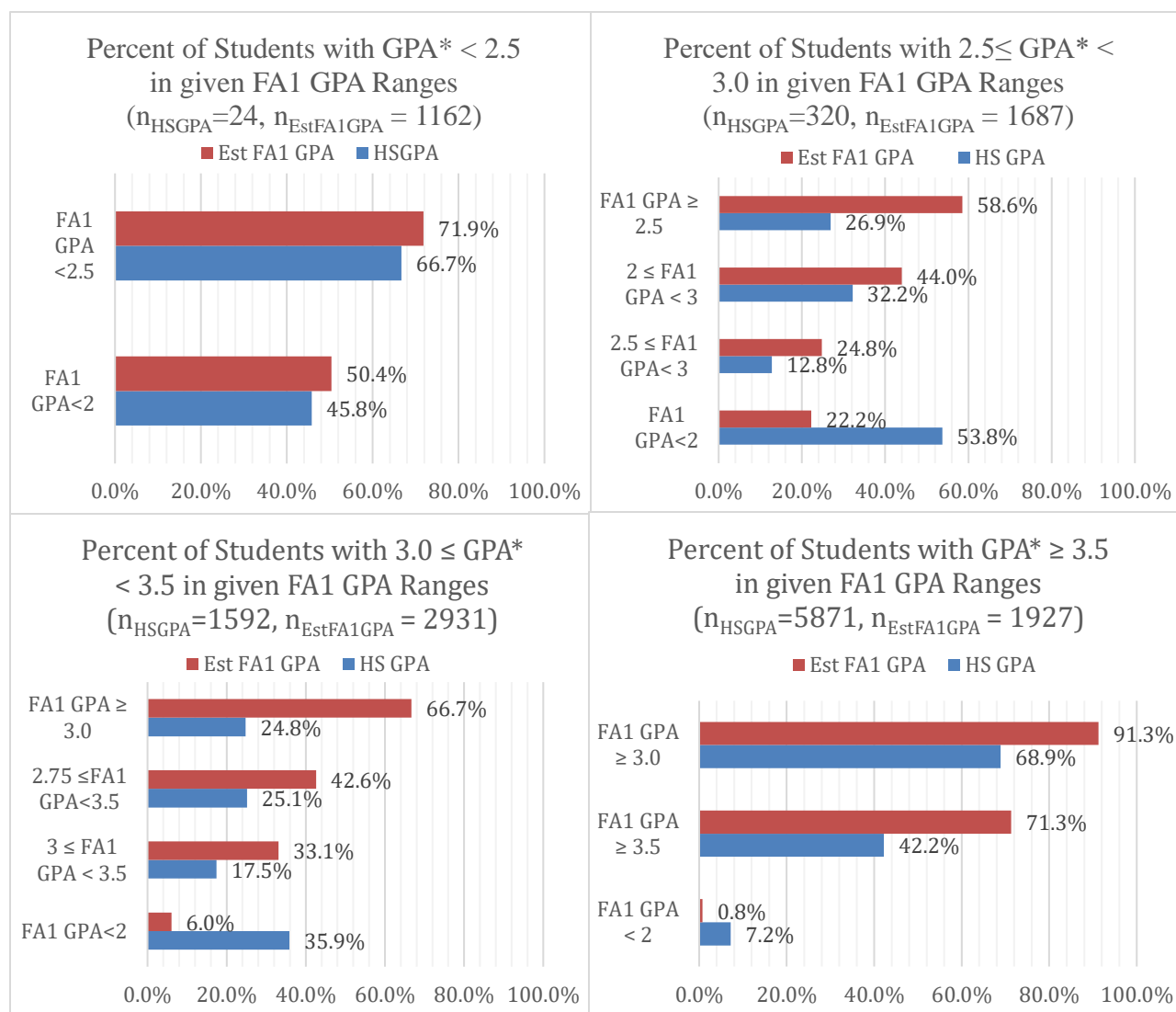
Figure 2. Comparison of high school GPA (HS GPA) and estimated first fall semester GPA (Est FA1 GPA). GPA ranges given in the titles are used both for HS GPA and Est FA1 GPA. n_{HSGPA} stands for number of students with High School GPA in the given range, $n_{EstFA1GPA}$ stands for number of students with estimated Fall 1 GPAs in the given range.

For students with GPA* in 3.5 – 4.0 range: The results in this range also supports the discussions above. Out of 1927 students who started with Est FA1 GPAs 3.5 – 4.0 range, 71.3% finished first fall semester with GPA 3.5 – 4.0 range. For the HS GPAs, the corresponding number of students and percentage are 5871 and 42.4%, respectively. Also, 91.3% of the students with Est FA1 GPAs in this range ended the semester with FA1 GPAs 3.0 and above, whereas 68.9% of the students with HS GPAs ended the semester with FA1 GPAs 3.0 and above. For this group of students, 0.8% with Est FA1 GPAs in this range ended up on probation, whereas 7.2% with HS GPAs ended up on probation.

In-State and Out-of-State Students

One piece of admissions data that had not previously been considered at our University for predicting student success in the first fall semester was in-state vs. out-of-state groupings. In-state students represented 61% of the cohort while out-of-state- students made up 39% of the cohort. We also decided to separate the small number of international students from the out-of-state students. Overall GPA statistics for students grouped by residency is presented in Table 4 and Figure 3. In-state students averaged the lowest FA1 GPA (2.85) while out-of-state students averaged slightly higher FA1 GPA of 2.94. International students had the highest mean FA1 GPA (3.28). We also observe from Figure 3 that the percent of international students who earned a FA1 GPA above 3.5 was higher compared to the in-state and out-of-state students. Similarly, the percent of international students who earned a FA1 GPA below 3.5 was lower compared to the in-state and out-of-state students. However, no statistical differences were found in FA1 GPA when comparing students from in-state, out-of-state and internationally ($P \geq 1.64$). Therefore, breaking student groups out based on their residence status was not a useful metric for predicting student success in their first semester.

Table 4. Sample size, means, median and standard deviation of high school GPA (HS GPA), first fall semester GPA (FA1 GPA), first Spring semester GPA (SP1 GPA), cumulative GPA at the end of first spring semester (SP1 Cum GPA), second Fall semester GPA (FA2 GPA) and cumulative GPA at the end of second fall semester (FA2 Cum GPA) for students in the cohort from 2007-2018 grouped by residency.

|	HS GPA	FA1 GPA	SP1 GPA	SP1 Cum GPA	FA2 GPA	FA2 Cum GPA
In-State						
Sample size	4740	4740	4265	4265	3091	3091
Mean	3.76	2.85	2.91	2.98	2.82	3.08
Median	3.84	3.07	3.19	3.15	3.00	3.16
St Dev	0.42	1.05	1.03	0.87	1.03	0.70
Out-of-State						
Sample size	2759	2759	2483	2483	1786	1786
Mean	3.80	2.94	3.06	3.09	2.94	3.15
Median	3.81	3.17	3.25	3.19	3.00	3.17
St Dev	0.37	0.96	0.85	0.73	0.85	0.58
International						
Sample size	233	233	217	217	173	173
Mean	3.52	3.28	3.35	3.36	2.94	3.25
Median	3.62	3.50	3.56	3.54	3.15	3.37
St Dev	0.47	0.78	0.76	0.63	0.91	0.65
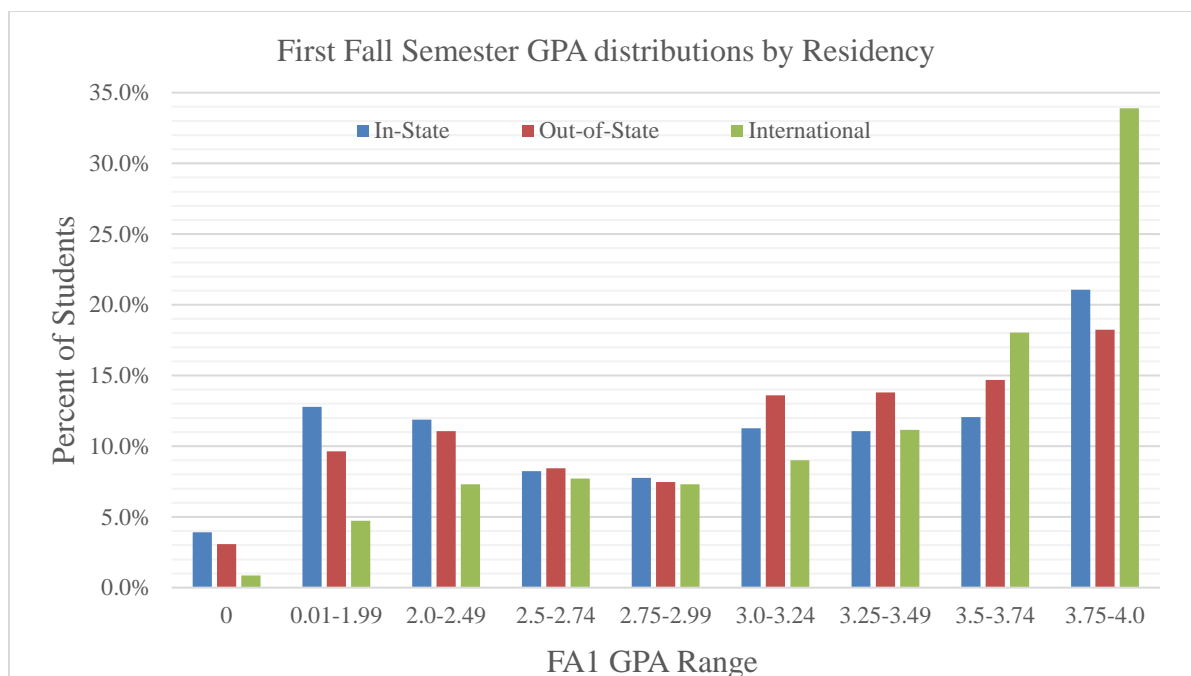
Figure 3. Comparison of first fall semester GPA (FA1 GPA) between in-state, out-of-state and international student grouping.

Conclusions

There is no one single predicting factor that can correctly identify all students who will struggle academically in college. For the students evaluated in this study, HS GPA was only a good predictor for students who had low HS GPA (below current admission standards, i.e., < 3.0) or outstanding HS GPA (> 4.0). In these cases, if you did poorly in high school you are going to do poorly in college, and if you did extremely well in high school, you are going to be successful at college. However, most students fall somewhere between 3.5-4.0 HS GPA range. We found that the Est FA1 GPA was a better predictor for FA1 GPA for these students. 67% of the students with an Est FA1 GPA in 3.0 – 3.5 range ended up with good grades (above 3.0 FA1 GPA) and 91% of the students with an Est FA1 GPA 3.5 or above ended up with good grades at the end of their first semester. The Est FA1 GPA was also a better tool to identify the at-risk students who might end up in probation at the end of their first semester.

Regressions coefficients used to create Est FA1 GPAs were calculated using data for all students from a given high school who then attended our university. Limiting data to students who are enrolled in the College of Engineering at University of Arkansas may produce regression coefficients that are even more useful for predicting first semester success for our students. These regressions are something we can develop as a College and could easily be created and used at other Universities. Using Est FA1 GPAs may improve academic advising for incoming freshman and better guide the process of deciding semester difficulty versus degree progress. Providing students with their Est FA1 GPA could help students with the transition from high school to college and potentially help them anticipate their own academic success. Specifically, we should consider modified advising for students with an Est FA1 GPA < 3.0 since these

students have a high chance of ending up on probation. These students should be given the option to modify the expected eight-semester degree plan and delay a science course to reduce their first semester load.

We also considered whether in-state residence would be a metric that could help predict student success, but we found no statistical differences in first semester GPAs when comparing in-state, out-of-state and international students. We conclude that students coming from out-of-state and even internally do not need to be advised differently solely because of their residence status.

Acknowledgment

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