

Comparing Success Rates in Thermodynamics: The Effect of Transfer Credits in Prerequisite Calculus and Physics Courses

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Abstract

Many mechanical engineering students earn transfer credit for calculus and physics courses. This paper examines the impact of transfer credits on academic success in a junior-level thermodynamics course, using data from 738 undergraduate students at the University of San Antonio from 2019 to 2022. Results show that students who transfer credit for Calculus I tend to perform better in thermodynamics, with a pass rate on the first attempt around 10 percentage points higher than those who earn credit for Calculus I at the University. Differences in pass rates for transfer credits in Calculus II and Physics I are less significant. The data suggests that students with high numbers of transfer credits have equivalent or higher academic success in thermodynamics compared to those with little or no transfer credits. A student satisfaction survey found that many students earn Calculus I credit while in high school and express high satisfaction with the instruction received. There is no significant differences in student satisfaction between community colleges and university Calculus or Physics courses. These findings shed light on the impact of transfer credits on academic success and student satisfaction in thermodynamics.

Introduction

A high percentage of mechanical engineering students at the University of Texas at San Antonio (UTSA) earn credit for foundational math and science classes outside of the University. Around two-thirds of the students earned credits for Calculus I outside of UTSA and only about one-third at UTSA. Calculus I is a major predictor of future success in science and engineering programs, hence it is critical that students master the course material [1]-[2]. The future success of transfer students is essential to a 4-year University like UTSA which has many transfer students. It is reported that transfer students often experience difficulty feeling part of the student community and this can negatively impact their future academic achievements [3]. UTSA, like many 4-year university engineering programs work with local community colleges to create a detailed semester-by-semester course plans for eventual transfer [4], some social and academic integration activities [5] as well as cohort activities for transfer students [6]. Studies often associate the grades earned in foundational Calculus and Physics classes to be linked with the level of preparation for subsequent engineering courses. This paper tracks where the credit was earned for Calculus I, Calculus II and Physics I courses, and then tracks subsequent academic success in a junior-level engineering courses, ME 3293 Thermodynamics I, which is a course that is rarely transferred into UTSA and only from another 4-year university.

Method

Student academic progress data was collected for students enrolling in ME 3293 Thermodynamics I from Spring 2019 to Fall 2022. Because the summer has a high percentage of repeat students and more students take the class with the intent to transfer back to another 4-year university, only the Spring and Fall semester data is evaluated. The thermodynamics course

has 40 to 60% pass rate, so only the first attempt of the course is tracked in this study. In total, 738 students were tracked over this 4-year period.

Data was collected on where each student earned credit for: Calculus I, Calculus II and Physics I. The Physics I is a calculus-based which is consistent with what is required in an accredited mechanical engineering program. The students are grouped based on where credit for the three foundational courses is earned.

Table 1 provides a summary of the data. For the Spring 2019 semester, a total of 97 students attempted ME 3293 Thermodynamics I for the first time, of which 61 had transfer credit for Calculus I, 49 students had transfer credit for Calculus II and 49 students had transfer credit for Physics I. The pass rate for each group is calculated, which is about 50 to 60% in the typical semester over the 4 years. The pass rate in thermodynamics of each group is calculated and the difference in the pass rate is shown in the table. For example, in Spring 2019, the pass rate was 52% for those earning Transfer credit for Calculus I and 36% for those having earned credit for Calculus I at UTSA, hence the pass rate difference is 16%. The difference in pass rate appears to be a better indicator of student preparation for a difficult engineering course since there are multiple instructors who regularly teach ME 3293 and it has been observed that pass rates vary with instructor. For the Spring 2019 semester, students with transfer credit for Calculus I have 16% higher pass rate in Thermodynamics I, transfer for Calculus II is 9% higher and transfer for Physics I is 6% higher. Table 1 shows the pass rate difference is almost always higher for Calculus I compared to Calculus 2 and Physics I.

Table 1. Students attempting ME 3293 for the 1st time based on where they earned credit for Calculus I, Calculus II, and Physics I. T=transfer credit, U=university credit earned at UTSA.

		Cal1-T	Cal1-U	Pass Rate Diff	Cal2-T	Cal2-U	Pass Rate Diff	Phyl-T	Phyl-U	Pass Rate Diff
	N	N	N		N	N		N	N	
Sp19	97	61	36	16%	49	48	9%	49	48	6%
Fa19	107	74	33	-3%	47	60	-3%	51	56	-4%
Sp20	79	53	26	22%	45	34	4%	36	43	7%
Fa20	111	78	33	8%	52	59	6%	45	66	13%
Sp21	108	66	42	8%	50	58	6%	45	63	5%
Fa21	100	59	41	11%	47	53	-9%	39	61	-8%
Sp22	62	47	15	17%	31	31	14%	28	34	-3%
Fa22	74	38	36	8%	27	47	2%	23	51	0%
Overall	738	476			348			316		
		64%		10%	47%		3%	43%		1%

Table 1 also shows the overall number of students transferring credit, where 64% of the 738 students transfer Calculus I, 47% transfer Calculus II, and 43% transfer Physics I. Similarly, the

table shows the cumulative difference in 1st attempt pass rate in ME 3293. It is 10% when Calculus I is earned by transfer credit, 3% when Calculus II is earned by transfer credit, and 1% when Physics I is earned by transfer credit. The cumulative data shows those earning transfer credit for Calculus II and Physics I is slightly better or equivalent to those with University credit for these courses. Overall, the data shows transfer students are performing at least as well as students who earn credit for Calculus II and Physic I at the University.

Figure 1 shows the pass rate difference data graphically. When the difference in pass rate is about 10% different, it is viewed as being significant for that semester and course. Visually, the data shows a positive difference where transfer students outperform university students for the three foundational classes. An attempt was made to understand why there is such variation, including the instructor teaching ME 3293 or the individual instructors teaching Calculus I, Calculus II and Physics I classes. The importance of the individual instructor is significant, yet the data is not conclusive and is not included in this paper. Probably the hardest data to collect is the transfer data. A number of community colleges have high transfer rates into UTSA, yet only the credit is currently recorded into the UTSA transcript, not the community college instructor or mode of instruction. It is expected that if the data would be available, it could be shown that some community college instructors are consistently doing better at helping students master foundational math/sci classes.

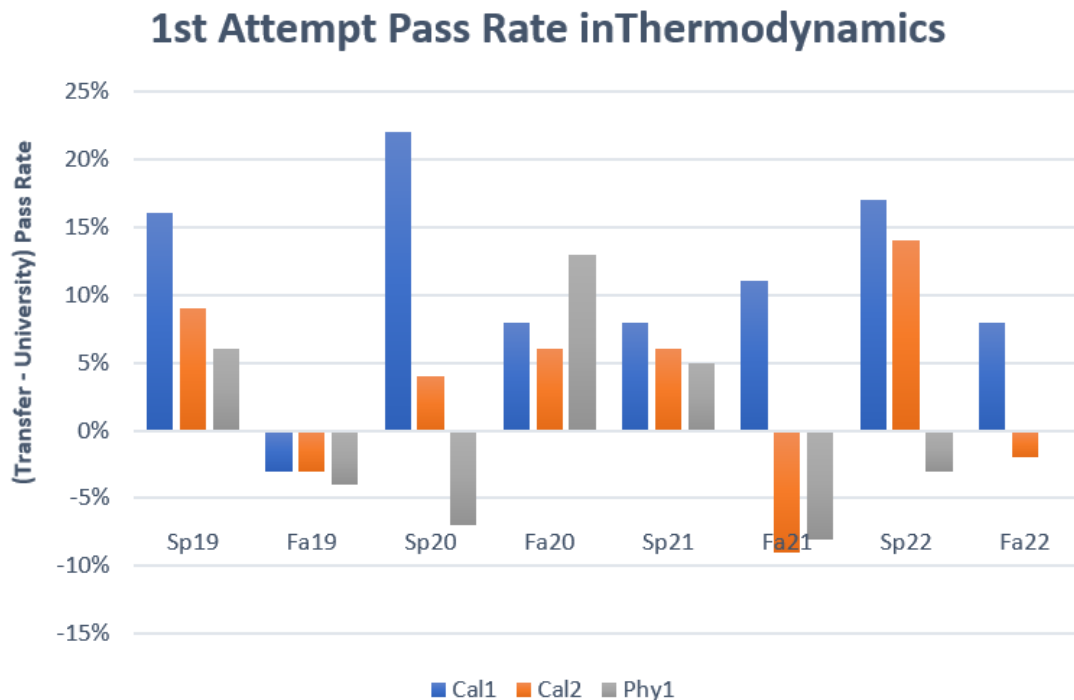


Figure 1. Transfer student pass rate compared to university student pass rate for three courses: Calculus I, Calculus II and Physics I, from Spring 2019 to Fall 2022.

Student Survey

A voluntary student survey was conducted to explore what may be causing the trends in the data, with the full survey reported in Ref. [7] and results pertinent to Calculus I and Physics I courses are reported here. The survey asked students to self-report where they earned credit for Calculus I and Physics I classes, then self-report the quality of instruction received in those courses on a likert-scale with 1=poor and 5=excellent. Students earned credit in either High School (HS), Community College (CC) or at UTSA. In some cases, the students reported they may have taken Calculus I when in high school, but retook Calculus I at the community college or UTSA. In cases where the class was repeated, only the final attempt where student earned credit for the course is used in the survey. The survey was completed by N=121 students in two junior level mechanical engineering class in Fall 2022 at UTSA.

Figure 2 shows the data for Calculus I course. The total number of students earning high-school credit (either AP or dual credit) was surprisingly high at 28 students which is 22% of the participating students. The number of transfer from community college was 50 students which is 40% of the survey participants. This indicates that 38% of the students earned credit for Calculus I at UTSA, which is consistent with data in Table 1 showing 36% over the 4-year period.

Figure 2 shows that the students report the quality of instruction in Calculus received at the high school is significantly higher than either at the Community College or UTSA. A statistical analysis shows the average is 4.71/5.0 for HS, 3.78/5.0 for CC and 3.48/5.0 for UTSA.

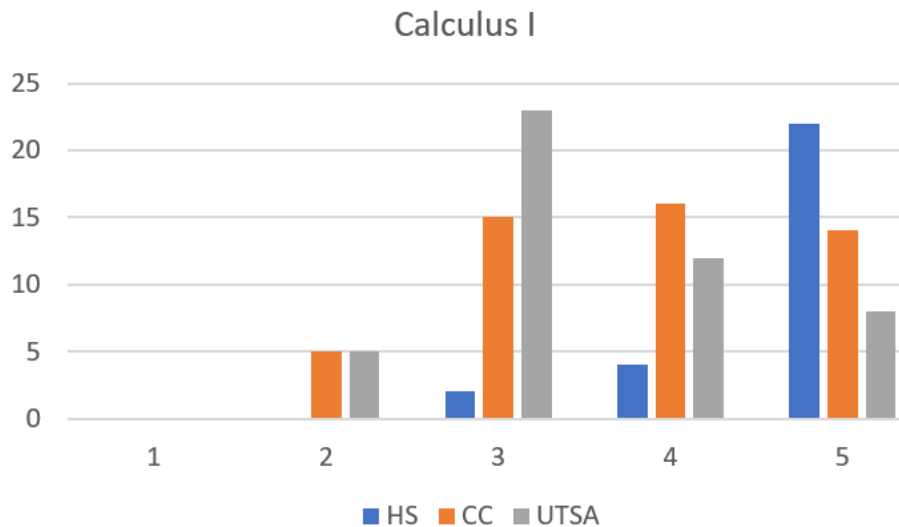


Figure 2. Student evaluation of quality of instruction in Calculus I, HS=high school, CC=community college, and UTSA, 1=poor and 5=excellent.

Figure 3 shows results for Physics I. Only a small number of students earned credit for Physics I in high school. In follow-up discussions with students, it was found that the Physics I at the high-school is often algebra-based and not calculus-based, hence they have to retake Physics I at either CC or UTSA. Only 7 students (6% of respondents) self-reported to have earned Physics I credit while in high school, yet the students are unanimous in reporting the quality of instruction

as being 5/5, the highest possible rating. The percent of students earning credit for Physics I at CC is also high at 41%, yet the rating is 3.36/5.0 for CC and 3.24/5.0 for UTSA. Hence the quality of instruction is similar between community college and the university.

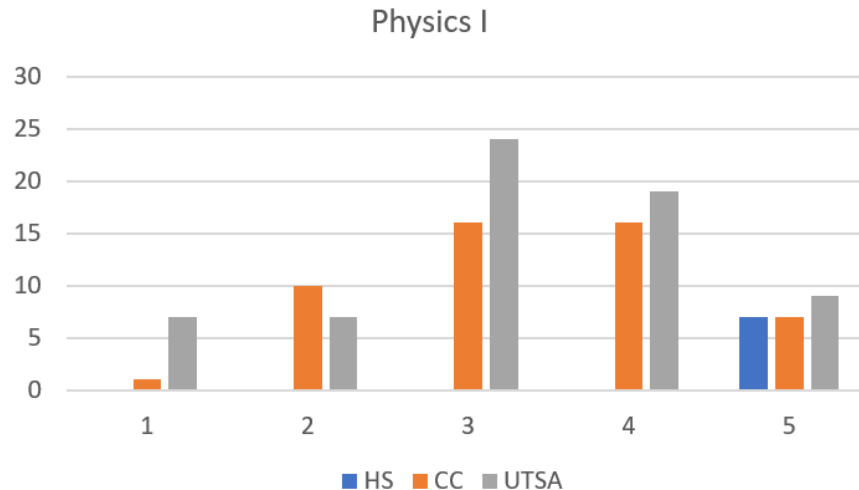


Figure 3. Student evaluation of quality of instruction in Physics I, HS=high school, CC=community college, and UTSA, 1=poor and 5=excellent.

The most significant difference in student success is likely to be linked to the quality of instruction in prerequisite courses, hence linked to students earning significant AP and dual credit for calculus and physics courses. These students are likely to also have a higher grade point average (GPA). This paper doesn't investigate the grade earned in Calculus I, Calculus II and Physics I with subsequent success in thermodynamics, nor the student's GPA at the time they take thermodynamics. It is reasonable to expect that students who earn college credit for Calculus & Physics courses before graduating from high school are likely to have higher GPA and higher pass rates in engineering courses, but this is not investigated in this paper.

Conclusions

This paper reports on the data for 738 students attempting ME 3293 Thermodynamics I for the first time in spring/fall semesters over a four year period from Spring 2019 to Fall 2022. For each student, it was determined where the student earned credit for Calculus I, Calculus II, and Physics I, either being transfer (primarily from local community colleges) or from the University (UTSA). The data shows that students earning Calculus I credit by transfer have a 10% higher pass rate on the first attempt for ME 3293. This is a significant difference. The pass rate was slightly higher if they earned transfer credit for Calculus II (3% higher) and transfer credit for Physics I (1% higher).

A student survey was conducted to help explain the data. The survey shows that students rate the quality of instruction much higher for Calculus I and Physics I received before graduation from high school, either as Advance placement (AP) or dual credit. The quality of instruction was not significantly different between community colleges and university for these courses. Student feedback shows some poor instruction as well as some excellent instruction at both community

college and the university. Data indicates that students with transfer credit for foundational math/sci courses perform as well as, if not better than, those students who take the foundational math/sci courses at the 4-year university, and this may be explained by the quality of instruction received.

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