Predicting Student Performance in Selected Engineering Courses from Introductory Physics Performance: A Multi-Course Regression Analysis

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Engineering curricula rely on many courses out of the major to build foundational knowledge and provide breadth within the programs. However, many pre-engineering students struggle to see the relevance of some lower-level math and science requirements in their academic plan. For example, at Penn State University almost all engineering students take at least one Physics course before declaring their chosen engineering major, but student evaluations and anecdotal evidence indicate pre-engineering students view Physics as a roadblock or gatekeeper course and unnecessary for their intended engineering degree. This perception is reinforced by the fact that there has been an increase in the number of pre-engineering students who take the required Physics course(s) elsewhere, even during the academic year, and transfer the credits back.

This paper examines students' performance in discipline-specific engineering courses in relation to their performance in introductory Physics courses and investigates whether differences exist between students who completed Physics at the University's flagship campus, University Park (UP), and those who completed it at one of the Commonwealth Campuses (CWC).

Serving a large undergraduate engineering student body across multiple campuses and encompassing multiple engineering disciplines, Penn State's College of Engineering is positioned to gain insights into the student population, course rigor across instructors and locations, and departmental expectations. Eight years of engineering students' Physics grades were analyzed and correlated with performance in subsequent courses in the students' academic plans. Initial results show trends, including relationships between Physics 1 and Physics 2, Physics 1 and Statics, and Physics 1 and Dynamics. Additional correlations were observed between Physics 2 and Circuits, as well as variations of Measurements and Instrumentation courses.

In response to these findings, several pedagogical solutions were implemented, such as sharing engineering homework problems and questions from engineering faculty with Physics faculty to help them better connect course material to pre-engineering students. The goal of this paper is to present these results and offer insight into improving engineering student success, illustrating the data-driven approach to decision-making process in the context of the engineering programs.

Key Words: Physics, introductory, transfer students, transfer credits

Background

Ensuring that students graduate from higher education, especially in engineering, has been a demanding undertaking for higher education institutions [1]-[2]. Similarly, the retention of students in engineering programs has been a concern and priority at many institutions for decades [3]. Students who leave engineering programs may leave college altogether, but many continue to pursue other fields that align better with their personal aspirations [4]. Although switching out of engineering does not represent a complete loss of students who will make meaningful contributions in their chosen fields, it does reflect a potential realignment of student interests that may support long-term personal and professional achievements.

Nevertheless, it is still paramount to support those who choose to stay in engineering by providing appropriate resources, guidance, and understanding of the factors that promote their success. Engineering is a demanding discipline, and academic performance, particularly in the first year, plays a critical role in determining students' persistence [5]. Some undergraduate engineering students struggle in their first year because of the rigor of required coursework, inadequate academic preparation from high school, and the significant time commitment needed to succeed. The students' academic performance may affect not only their financial aid but also their confidence and sense of belonging within the discipline.

Most attrition among engineering students continues to occur within the first two years, before many students have taken discipline-specific engineering courses [6]. Many of these students face challenges in math and science courses that are introductory for their future engineering courses [3]. In the United States, the retention rate of engineering students averages about 50%, suggesting half of students entering engineering leave school prior to graduation [3] or switch from engineering to non-engineering programs [7]. The societal impact of high student attrition becomes particularly concerning when it occurs in science, technology, engineering, or mathematics (STEM) disciplines, as these fields are critical for maintaining a nation's global competitiveness [8]. In fact, workers in STEM disciplines comprise 23% of the national workforce; however, the percentage of workers with a bachelor's degree in these STEM fields remains below 45% [9]. Supporting student success in engineering should therefore be considered a national priority, particularly given the growing shortage of skilled STEM professionals [10].

There have been many studies to correlate performance in college math courses to overall engineering student success [11]-[13]. Some studies show higher-level mathematics courses as significant predictors of student performance, along with foundational physical science courses when taken synergistically with mathematics [14]. A recent study found that key predictors of engineering student success included first and second year GPAs and SAT math scores. Additional factors, although not consistently ranked highly by all correlation models, include performance in Physics 1, Chemistry 1, and Calculus 1, respectively [15].

Purpose

In this paper, performance in early Physics courses serves as the central focus of this work. The study examines eight years of engineering students' Physics grades and their subsequent performance in courses along with their academic plan. Additionally, it also evaluates whether differences emerge in subsequent engineering courses' final grades based on the location where the Physics courses were taken—University Park (also referred to as UP campus) or Commonwealth Campus (also referred to as CWC). A Commonwealth Campus is part of the Penn State University, separated geographically and often offers smaller class sizes. The specific correlations analyzed include relationships between Physics 1 and Physics 2; Physics 1 and Statics; Physics 1 and Dynamics; Physics 2 and Circuits; and Physics 2 and Measurements and Instrumentation courses.

With this context, this study seeks to answer the following research questions (RQs):

RQ1: What differences are observed in student performance in Physics courses between where the courses were taken, i.e., UP campus and CWC ?

RQ2: How do student outcomes in subsequent engineering courses vary by prior performance in foundational Physics courses and by the campus location where the courses were taken?

Method

The investigators used "big" institutional data to gather information across multiple campuses, academic years, and courses. The team analyzed a class enrollment dataset of College of Engineering students from Penn State University whose first term is between summer or fall 2016 to summer or fall 2023. The data set comprises 33,519 observations for Physics 1 and 3,977 observations for Physics 2. Table 1 provides the sample size for each course pairing of the analysis.

Table 1: Data Set

Correlation	Sample Size, n
Physics 1 to Physics 2	15,722
Physics 1 to Statics and Strengths of Materials	3,744
Physics 1 to Statics	8,341
Physics 1 to Dynamics	8,206
Physics 2 to Circuits	2,791
Physics 2 to Measurement and Instrumentation	1,444

For each course pairing, the sample was restricted to students who completed both the introductory Physics course and the corresponding follow-on course. Students were excluded from a given analysis if they completed only one of the two courses or if they completed either course at both the UP campus and Commonwealth campus. This restriction ensured that each student could be clearly classified into a single class campus for both courses, avoiding ambiguity in campus assignment.

If a student attempted a course multiple times, the highest attempt was used for this analysis for consistency and to base the mastery or highest level of understanding of the Physics course to the subsequent course performance.

Chi-square Analysis

First, Chi-square analyses were conducted to test whether there are statistically significant associations between class campus of the introductory Physics course and student performance across each of the follow-on courses. Student performance in the follow-on course was categorized into two groups: grades below C and grades of C or higher. Campus categories were defined based on where the relevant Physics course was completed: UP campus and CWC.

Contingency tables were constructed for each course pairing, cross-classifying class campus by performance category (< C vs. ≥ C). Table 2 summarizes the observed counts of the contingency tables.

Table 2: Observed Head Counts (by Grouped Grades) of Follow-on Courses by Class Campus of the Introductory Physics Course

Course Pairing	Class Campus	< C	≥ C	Total	%≥ C
Physics 1 to Physics 2	Took Physics 1 Only at CWC	869	6126	6995	88
	Took Physics 1 Only at UP	822	6851	7673	89
	Total	1691	12977	14668	88
Physics 1 to Statics and Strengths of Materials	Took Physics 1 Only at CWC	59	387	446	87
	Took Physics 1 Only at UP	194	2852	3046	94
	Total	253	3239	3492	93
Physics 1 to Statics	Took Physics 1 Only at CWC	587	3521	4108	86
	Took Physics 1 Only at UP	563	3102	3665	85
	Total	1150	6623	7773	85
Physics 1 to Dynamics	Took Physics 1 Only at CWC	256	2908	3164	92
	Took Physics 1 Only at UP	291	4131	4422	93
	Total	547	7039	7586	93
Physics 2 to Circuits	Took Physics 2 Only at CWC	203	1039	1242	84
	Took Physics 2 Only at UP	165	1172	1337	88
	Total	368	2211	2579	86
Physics 2 to Measurement and Instrumentation	Took Physics 2 Only at CWC	12	559	571	98
	Took Physics 2 Only at UP	3	824	827	100
	Total	15	1383	1398	99

Table 3 summarizes the Chi-square statistics. Because the "< C" category of the "Measurement and Instrumentation" course contained very small sample sizes, as shown in Table 2, Chi-square is not the appropriate test and was not run on that course pair. Statistically significant associations were consistently observed between class campus of the introductory Physics course and the likelihood of earning a grade below C (all $p < 0.001$) in each of the follow-on courses. These results indicate that differences in student performance across class campus are unlikely to be due to random variation alone.

Table 3: Summary of Chi-square Statistics

Introductory Course	Subsequent Course	Sample Size, n	Chi_Square	df	p_value
Physics 1	Physics 2	14,668	10.3268475	1	0.00131109
Physics 1	Statics and Strengths of Materials	3,492	26.2294049	1	3.0317E-07
Physics 1	Statics	7,773	1.68281891	1	0.19455031
Physics 1	Dynamics	7,586	6.06398786	1	0.01379658
Physics 2	Circuits	2,579	0.5989239	1	0.4389889
Physics 2	Measurement and Instrumentation	1,398	N/A		N/A

Multiple Linear Regression Analysis

The second step was to use **linear regression models** to examine the relationship between student performance in Physics courses and follow-on engineering courses. This is done for each course pairing. For each model, the dependent variable was the course outcome in the follow-on course (e.g., Physics 2, statics, dynamics, etc.), and the key independent variable was performance in the introductory Physics course (e.g., Physics 1 or Physics 2).

Using Physics 1 and Physics 2 as an example. The dependent variable was the students' highest Physics 2 grade, measured on a 4.0 grade-point scale. The primary independent variable was the students' highest Physics 1 grade, also measured on a 4.0 scale. Because both Physics 1 and Physics 2 may be completed at either the UP campus or a CWC campus, the regression model included two campus indicators as categorical variables: one for the campus where Physics 1 was completed and one for the campus where Physics 2 was completed, coded as 0 = UP campus/UP and 1 = CWC/CWC. This coding allows the UP campus to serve as the reference group. In addition, an interaction term between the class campus of the two courses was incorporated to capture whether the relationship between course performances differed by campus context.

The regression model was specified as:

$$\begin{aligned}\text{Physics 2 Grade}\\ &= \beta_0 + \beta_1(\text{Physics 1 Grade}) + \beta_2(\text{Physics 1 Campus}) + \beta_3(\text{Physics 2 Campus})\\ &+ \beta_4(\text{Physics 1 Campus} \times \text{Physics 2 Campus}) + \varepsilon\end{aligned}$$

It suggests the class campus effects on Physics 2 Performance as illustrated in Figure 1.

	Physics 2 UP Campus	Physics 2 CWC Campus
Physics 1 UP Campus	β_1 (Baseline)	$\beta_1 + \beta_3$
Physics 1 CWC Campus	$\beta_1 + \beta_2$	$\beta_1 + \beta_2 + \beta_3 + \beta_4$

Figure 1: Class Campus Effects on Physics 2 Performance

where

- β_1 represents the association between Physics 1 and Physics 2 grades, holding campus location constant;
- β_2 captures the difference in Physics 2 performance between students who completed Physics 1 at a CWC versus the UP campus;
- β_3 captures the difference in Physics 2 performance between students who completed Physics 2 at a CWC versus the UP campus; and
- β_4, the interaction term, assesses whether the effect of Physics 1 campus varies depending on the campus where Physics 2 was taken.

Model fit was evaluated using R^2 and adjusted R^2, and statistical significance of predictors was assessed using standard regression inference.

Results

Table 4 summarizes the statistics of the six regression models, and Tables 5.1 to 5.6 show the t-test results.

Table 4: Regression Model Summary Statistics

Course Pairing	Multiple R	R Square	Adjusted R Square	Standard Error	Observations
Physics 1 vs. Physics 2	0.5591199	0.3126150	0.3124275	0.8973096	14668
Physics 1 vs. Statics and Strengths of Materials	0.4511693	0.2035537	0.2026401	0.8917206	3492
Physics 1 vs. Statics	0.4805827	0.2309597	0.2305637	1.0786460	7773
Physics 1 vs. Dynamics	0.4290158	0.1840546	0.1836241	0.8825235	7586
Physics 2 vs. Circuits	0.5209296	0.2713676	0.2702353	0.9894171	2579
Physics 2 vs. Measurement and Instrumentation	0.2042866	0.0417330	0.0396708	0.5359398	1398

Physics 1 → Physics 2

In this model for predicting Physics 2 performance demonstrated moderate explanatory power ($R^2 = 0.313$), indicating that approximately 31% of the variance in Physics 2 grades is explained by Physics 1 performance and campus factors. Physics 1 grade was a strong and statistically significant positive predictor of Physics 2 performance ($\beta = 0.721$, $p < 0.001$), suggesting substantial continuity in academic performance between the two courses.

Table 5.1 t-test: Physics 1 to Physics 2

term	estimate	std.error	statistic	p.value	conf.low	conf.high
(Intercept)	0.49761	0.02930	16.98078	0.00000	0.44017	0.55505
Physics 1 Grade	0.72129	0.00922	78.21615	0.00000	0.70322	0.73937
Physics 1 Campus	-0.79591	0.04114	-19.34835	0.00000	-0.87655	-0.71528
Physics 2 Campus	0.70710	0.03935	17.96812	0.00000	0.62996	0.78424
Physics 1 Campus: Physics 2 Campus	0.17092	0.05696	3.00061	0.00270	0.05927	0.28257

Campus effects were also statistically significant. Students who completed Physics 1 at Commonwealth campuses performed significantly lower in Physics 2 compared to those from the UP campus ($\beta = -0.796$, $p < 0.001$), after controlling for prior performance. In contrast, taking Physics 2 at a Commonwealth campus was associated with higher Physics 2 grades ($\beta = 0.707$, $p < 0.001$).

Importantly, a statistically significant interaction between Physics 1 campus and Physics 2 campus was observed ($\beta = 0.171$, $p = 0.003$), indicating that the effect of Physics 1 campus on Physics 2 performance depends on where Physics 2 is taken. Specifically, the performance gap associated with completing Physics 1 at a Commonwealth campus is reduced when Physics 2 is also taken at a Commonwealth campus, suggesting that alignment between preparation and instructional context may mitigate differences in student outcomes. This pattern may be influenced by variation in instructional practices, grading standards, or course rigor across campuses.

Physics 1 → Subsequent Engineering Courses (Statics and Strengths of Materials, Statics, and Dynamics)

Table 5.2 t-test: Physics 1 to Statics and Strengths of Materials

term	**estimate**	**std.error**	**statistic**	**p.value**	**conf.low**	**conf.high**
(Intercept)	1.70940	0.04947	34.55467	0.00000	1.61241	1.80639
Physics 1 Grade	0.48084	0.01693	28.39988	0.00000	0.44764	0.51404
Physics 1 Campus	-0.57260	0.05076	-11.27986	0.00000	-0.67212	-0.47307
Statics and Strengths of Materials Campus	1.18054	0.28272	4.17563	0.00003	0.62622	1.73485
Physics 1 Campus: Statics and Strengths of Materials Campus	-1.02601	0.30053	-3.41405	0.00065	-1.61524	-0.43679

Table 5.3 t-test: Physics 1 to Statics

term	**estimate**	**std.error**	**statistic**	**p.value**	**conf.low**	**conf.high**
(Intercept)	0.99486	0.04206	23.65483	0.00000	0.91242	1.07730
Physics 1 Grade	0.64759	0.01373	47.16866	0.00000	0.62068	0.67451
Physics 1 Campus	-0.86292	0.06382	-13.52036	0.00000	-0.98803	-0.73781
Statics Campus	0.18987	0.12668	1.49888	0.13395	-0.05845	0.43819
Physics 1 Campus: Statics Campus	0.53444	0.14174	3.77068	0.00016	0.25660	0.81228

Table 5.4 t-test: Physics 1 vs. Dynamics

term	**estimate**	**std.error**	**statistic**	**p.value**	**conf.low**	**conf.high**
(Intercept)	1.47727	0.03990	37.02466	0.00000	1.39906	1.55549
Physics 1 Grade	0.46556	0.01272	36.60566	0.00000	0.44063	0.49049
Physics 1 Campus	-0.58132	0.04026	-14.43940	0.00000	-0.66023	-0.50240
Dynamics Campus	0.82473	0.07085	11.64018	0.00000	0.68584	0.96362
Physics 1 Campus: Dynamics Campus	-0.14259	0.08224	-1.73391	0.08297	-0.30380	0.01862

Across subsequent engineering courses, Physics 1 performance remained a consistently strong predictor of student outcomes (all $p < 0.001$), although explanatory power decreased relative to Physics 2 (R^2 ranging from 0.18 to 0.23).

Campus effects were again significant and consistent. Completing Physics 1 at a Commonwealth campus was associated with lower performance in all three courses (β ranging from −0.57 to −0.86, all $p < 0.001$). In contrast, the effect of where the subsequent course was taken varied by course.

Interaction effects revealed important differences across courses:

- **Statics & Strengths of Materials:** A significant negative interaction ($\beta = -1.026$, $p < 0.001$) indicates that the disadvantage associated with Commonwealth-campus Physics 1 is amplified when the subsequent course is also taken at a Commonwealth campus.

- **Statics:** A significant positive interaction ($\beta = 0.534$, $p < 0.001$) suggests that the disadvantage associated with Commonwealth-campus Physics 1 is reduced when students remain at Commonwealth campuses. Students taking Physics 1 at a Commonwealth campus showed lower outcomes ($\beta = -0.863$, $p < 0.001$). The Statics campus effect was not statistically significant ($\beta = 0.190$, $p = .134$). However, the interaction term was positive and significant ($\beta = 0.534$, $p < 0.001$), indicating that students taking both courses at a Commonwealth campus performed better than expected relative to the baseline.

- **Dynamics:** The interaction was not statistically significant ($p = 0.083$), indicating that campus effects operate largely independently in this course.

Taken together, these results suggest that while prior preparation consistently predicts subsequent performance, the effect of class campus varies across courses, with some courses showing mitigation effects and others showing amplification.

Physics 2 → Circuits

Table 5.5 t-test: Physics 2 to Circuits

term	estimate	std.error	statistic	p.value	conf.low	conf.high
(Intercept)	0.84873	0.07605	11.15998	0.00000	0.69960	0.99785
Physics 2 Grade	0.64442	0.02411	26.72565	0.00000	0.59714	0.69170
Physics 2 Campus	-0.82993	0.05353	-15.50291	0.00000	-0.93490	-0.72496
Circuits Campus	0.77831	0.28722	2.70976	0.00678	0.21509	1.34152
Physics 2 Campus: Circuits Campus	0.10130	0.29300	0.34572	0.72958	-0.47324	0.67583

Physics 2 performance was a strong predictor of Circuits outcomes ($\beta = 0.644$, $p < 0.001$), with the model explaining approximately 27% of the variance ($R^2 = 0.271$). Students who completed

Physics 2 at a Commonwealth campus performed significantly lower in Circuits ($\beta = -0.830$, $p < 0.001$), while taking Circuits at a Commonwealth campus was associated with higher grades ($\beta = 0.778$, $p = 0.007$). However, the interaction between Physics 2 campus and Circuits campus was not statistically significant ($p = 0.730$), indicating that campus effects are additive rather than dependent on class campus.

Physics 2 → Measurement and Instrumentation

Table 5.6 t-test: Physics 2 to Measurement and Instrumentation

term	estimate	std.error	statistic	p.value	conf.low	conf.high
(Intercept)	3.48331	0.05374	64.82305	0.00000	3.37791	3.58871
Physics 2 Grade	0.11803	0.01658	7.11792	0.00000	0.08550	0.15055
Physics 2 Campus	-0.20103	0.02830	-7.10408	0.00000	-0.25653	-0.14552
Measurement and Instrumentation Campus	-0.24646	0.51679	-0.47691	0.63349	-1.26011	0.76718
Physics 2 Campus: Measurement and Instrumentation Campus	0.13256	0.52239	0.25376	0.79971	-0.89207	1.15719

Physics 2 performance remained a statistically significant predictor ($\beta = 0.118$, $p < 0.001$) for performance in Measurement and Instrumentation, but the model explained substantially less variance ($R^2 = 0.059$), indicating weaker predictive relationships. Physics 2 campus was significantly associated with lower performance ($\beta = -0.201$, $p < 0.001$), while neither the subsequent course campus nor the interaction term was statistically significant.

Overall Pattern

Across models, prior performance in the introductory Physics courses is the strongest and most consistent predictor of subsequent outcomes, particularly within closely aligned course sequences. However, campus effects reveal that class campus, especially that of the introductory Physics course, is systematically associated with performance differences in the subsequent course, even after controlling for prior grades.

- Preparation effect: Students from Commonwealth campuses tend to perform worse, even after controlling for prior grades.
- Course Campus effect: Subsequent course location often influences observed grades. Campus effects vary in complexity.
- Interaction effect: In some courses, the difference in class campus where prerequisite and downstream courses are taken either mitigates or amplifies performance differences, while in others no interaction is observed.

These findings suggest that student performance is shaped not only by prior achievement but also by the interaction between preparation context and instructional environment, and that these dynamics differ across disciplines and courses. In particular, students who take the introductory

Physics course at Commonwealth campus tend to have lower outcomes in subsequent courses, while the location of the subsequent course has a more variable and sometimes positive association.

Charts and Descriptive Tables

To make the findings more accessible to stakeholders, bar charts and descriptive tables were created to present results in a clear and intuitive manner, minimizing reliance on statistical terminology that may be less familiar to a broader audience. These visualizations also reveal nuanced patterns that may not be readily apparent from statistical tests alone.
Figure 2.1 and Table 6.1 illustrate the course pair of Physics 1 and Physics 2, highlighting differences in Physics 2 grades across instructional locations, University Park and the Commonwealth Campuses, based on students' Physics 1 letter grades and the campus where Physics 1 was completed.

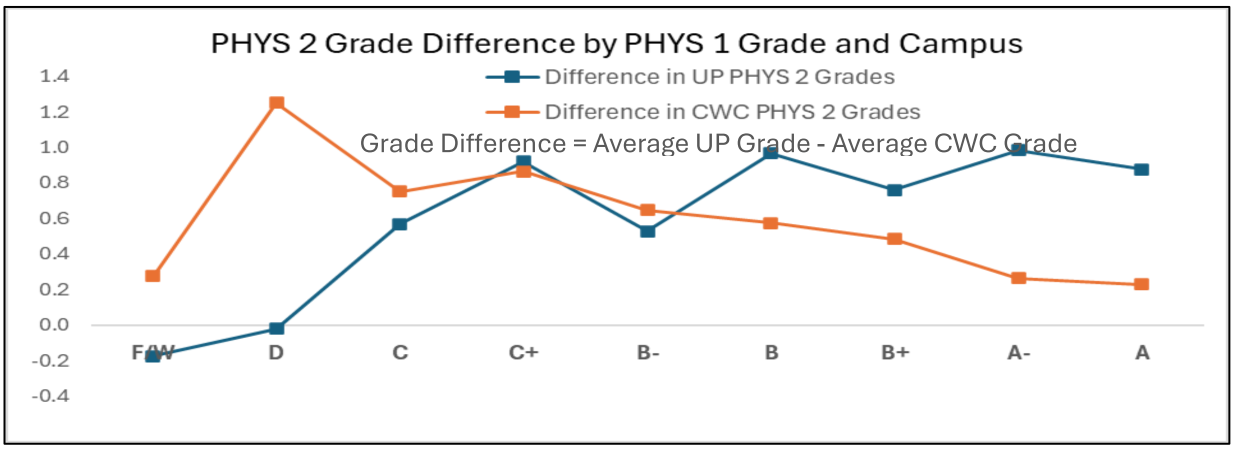

Figure 2.1: Difference in Physics 2 grades for both UP campus and CWC campus delivery based on Physics 1 grades from UP campus or Commonwealth campus delivery

Table 6.1: Physics 1 to Physics 2 Performance

		Average PHYS 2 Grade (Taken at UP)					Average PHYS 2 Grade (Taken at CWC)				
PHYS 1 Grade Point	PHYS 1 Grade	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	76	1.49	2	1.67	-0.17	17	2.37	35	2.10	0.28
1	D	113	0.98	7	1.00	-0.02	9	2.30	74	1.05	1.25
2	C	1407	1.86	71	1.30	0.57	144	2.83	1085	2.08	0.75
2.33	C+	610	2.15	42	1.23	0.92	60	3.05	602	2.18	0.87
2.67	B-	804	2.35	37	1.82	0.53	76	3.10	764	2.45	0.65
3	B	1091	2.57	81	1.60	0.97	92	3.30	1022	2.72	0.58
3.33	B+	774	2.86	57	2.09	0.76	55	3.41	690	2.92	0.48
3.67	A-	710	3.11	65	2.12	0.99	37	3.41	749	3.14	0.26
4	A	1525	3.58	149	2.70	0.88	73	3.78	1463	3.55	0.23
Total		7110	2.63	511	1.98	0.65	563	3.16	6484	2.77	0.39

H.C.= Head Count

For students completing Physics 2 at University Park, those who previously took Physics 1 at a Commonwealth Campus earned 0.65 grade point lower in Physics 2 than students who completed Physics 1 at University Park. For Physics 2 delivered at a Commonwealth Campus, students who previously completed Physics 1 at a Commonwealth Campus still earned 0.39 grade point lower.

Table 6.1 provides additional details. For example, for students completing Physics 2 at University Park, those who previously received an "A-" from Physics 1 at University Park scored 3.11 on average in Physics 2, whereas those who also received an "A-" but from a Commonwealth campus scored 2.12 on average in Physics 2. That's .99 grade point difference, almost one letter grade, showing that not all students maintain the same level of performance across courses when the class campus is different.

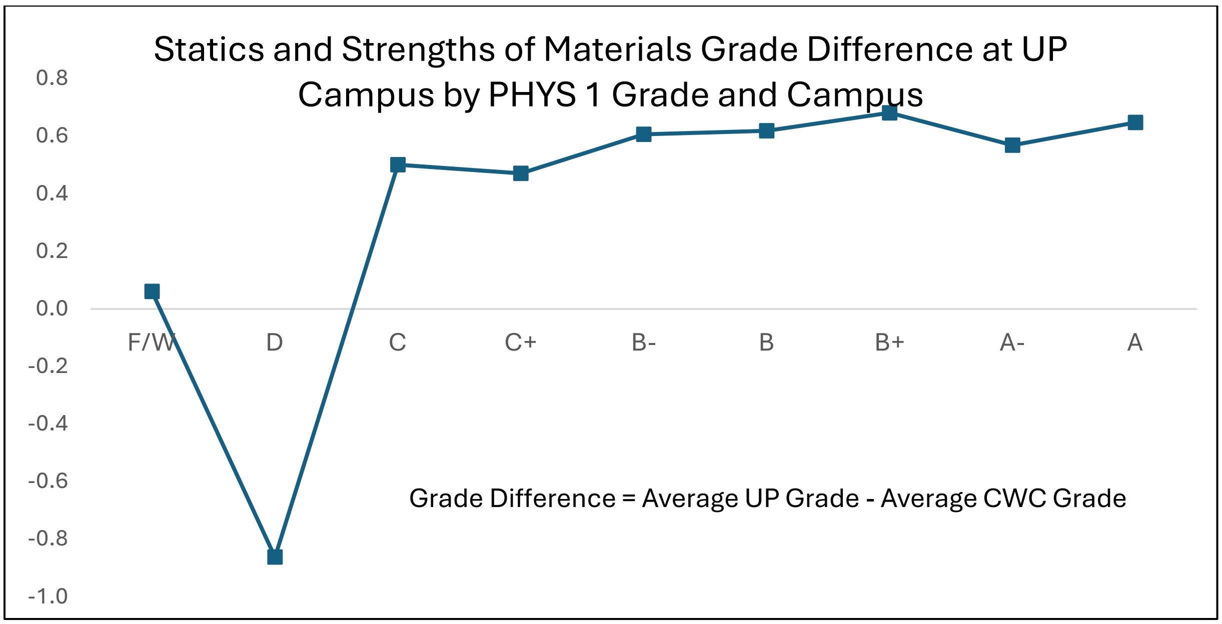

Figure 2.2: Difference in Statics and Strengths of Materials grades for University Park delivery based on Physics 1 grades from University Park or Commonwealth Campus delivery

For the Physics 1 to Statics and Strengths of Materials comparison, Figure 2.2 presents only the results for the course offered at the UP campus and the differences based on where students completed their Physics 1 course. The Statics and Strengths of Materials is a unique five-credit-hour course required in the academic plan for select majors in the College of Engineering, so the offering of this course at Commonwealth campuses has been sparse with no data for some of the Physics 1 grades (e.g. no student with a B- in Physics 1 took this course at a Commonwealth campus). Because of this data gap, only a single plot is shown. Combined with Table 6.2, the results show an average of 0.42 grade point difference in the Statics and Strengths of Materials course between students who took Physics 1 at the UP campus and those who completed it at a Commonwealth campus.

Table 6.2: Physics 1 to Statics and Strengths of Materials Performance

		Average Statics and Strengths of Matls Grade (Taken at UP)					Average Statics and Strengths of Matls Grade (Taken at CWC)				
PHYS 1 Grade Point	PHYS 1 Grade	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	90	2.20	7	2.14	0.06	1	4.00	3	1.33	2.67
1	D	73	1.81	1	2.67	-0.86	1	3.67			
2	C	712	2.56	58	2.06	0.50	3	3.78	14	1.41	2.37
2.33	C+	310	2.95	20	2.48	0.47	3	4.00	6	1.89	2.11
2.67	B-	383	2.99	33	2.38	0.61			16	2.60	
3	B	434	3.15	55	2.53	0.62	1	4.00	13	2.69	1.31
3.33	B+	336	3.32	37	2.64	0.68	1	3.67	8	2.00	1.67
3.67	A-	219	3.42	44	2.85	0.57			10	3.53	
4	A	479	3.70	93	3.05	0.65			28	3.83	
Total		3036	3.04	348	2.62	0.42	10	3.87	98	2.76	1.11

H.C.= Head Count

For the Physics 1 to Statics comparison, Figure 2.3 shows a difference in Statics performance based on the location where students completed Physics 1. For students who completed Statics at University Park, those who took Physics 1 at a Commonwealth Campus earned Statics at 0.65 grade point lower than students who took Physics 1 at the University Park. In contrast, for Statics delivered at a Commonwealth Campus, students who took Physics 1 at the University Park performed slightly better (+0.24 grade point).

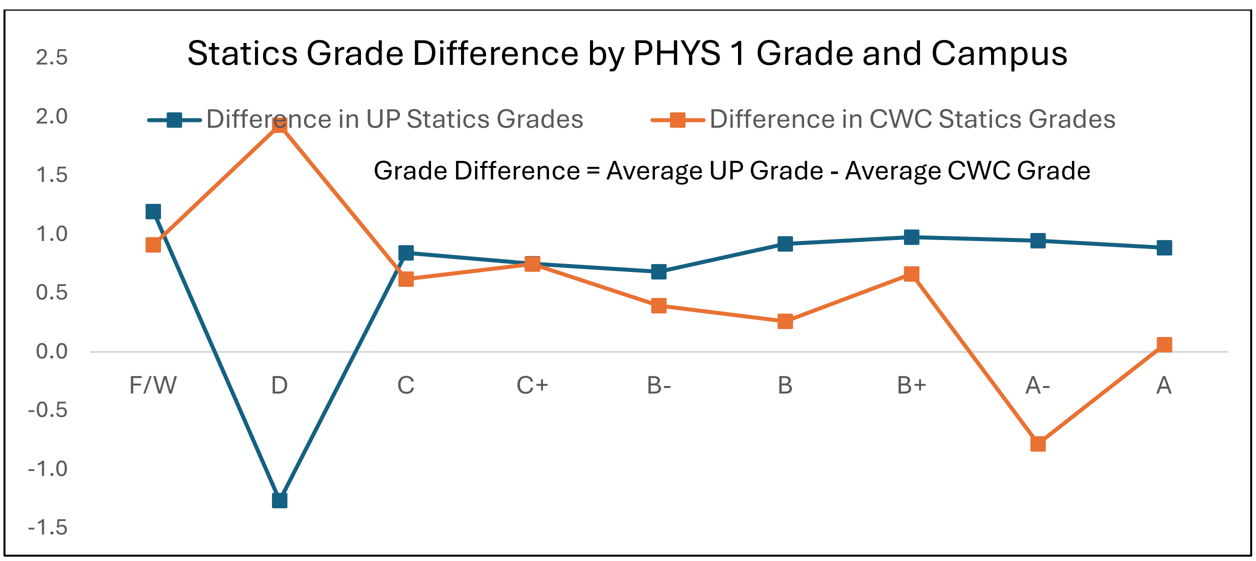

Figure 2.3: Difference in Statics grades for both UP campus and Commonwealth campus delivery based on Physics 1 grades from University Park or Commonwealth Campus delivery

Table 6.3: Physics 1 to Statics Performance

		Average Statics Grade (Taken at UP)					Average Statics Grade (Taken at CWC)				
PHYS 1 Grade Point	PHYS 1 Grade	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	113	1.53	3	0.33	1.19	4	2.00	85	1.09	0.91
1	D	98	1.40	1	2.67	-1.27	3	3.22	76	1.29	1.93
2	C	842	2.22	49	1.38	0.84	15	2.73	686	2.11	0.62
2.33	C+	332	2.45	22	1.70	0.75	5	3.07	344	2.32	0.75
2.67	B-	392	2.59	34	1.91	0.68	7	2.95	470	2.56	0.39
3	B	569	3.01	51	2.09	0.92	12	3.08	575	2.82	0.26
3.33	B+	369	3.24	33	2.26	0.98	4	3.67	408	3.00	0.66
3.67	A-	303	3.29	41	2.35	0.95	10	2.43	413	3.21	-0.78
4	A	573	3.65	78	2.77	0.89	14	3.57	739	3.51	0.06
Total		3591	2.79	312	2.14	0.65	74	2.98	3796	2.74	0.24

H.C.= Head Count

For the Physics 1 to Dynamics comparison, Figure 2.4 shows a continued difference in student performance in Dynamics based on the location where students completed Physics 1. For students who completed Dynamics at University Park, those who previously took Physics 1 at a Commonwealth Campus earned Dynamics grades 0.55 grade point lower than their peers who completed Physics 1 at University Park. For Dynamics delivered at a Commonwealth Campus, students who also completed Physics 1 at a Commonwealth Campus performed 0.46 grade point lower than those who completed Physics 1 at University Park, indicating some differences.

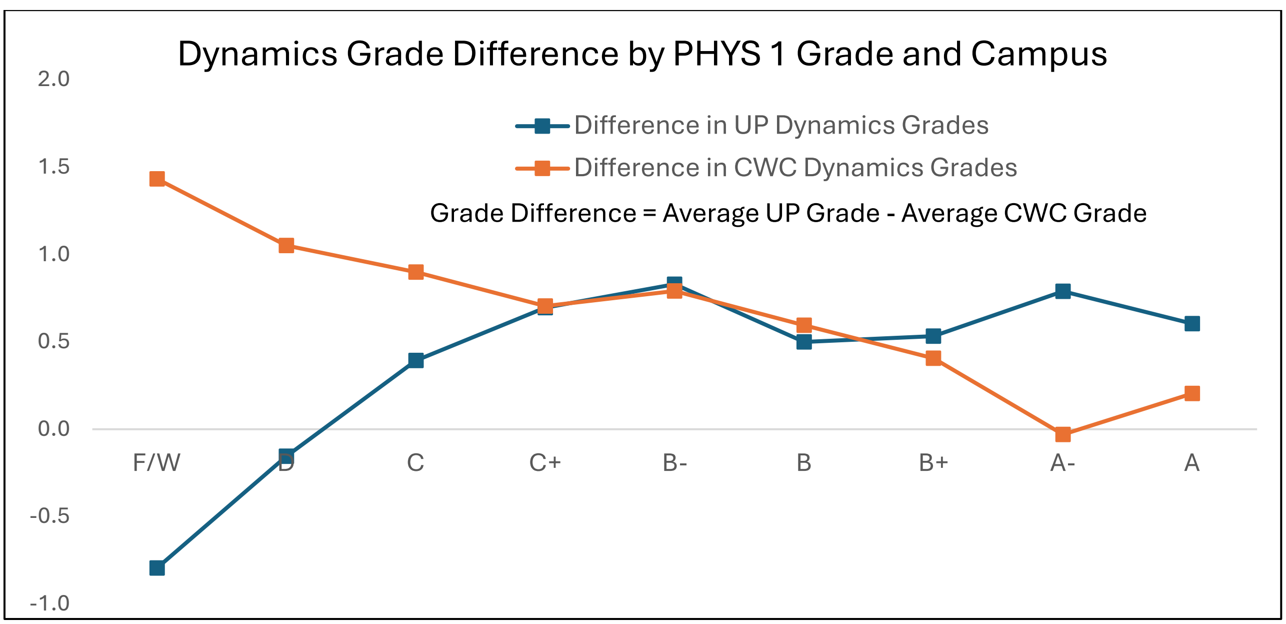

Figure 2.4: Difference in Dynamics grades for both UP campus and Commonwealth campus delivery based on Physics 1 grades from University Park or Commonwealth Campus delivery

Table 6.4: Physics 1 to Dynamics Performance

		Average Dynamics Grade (Taken at UP)					Average Dynamics Grade (Taken at CWC)				
PHYS 1 Grade Point	PHYS 1 Grade	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades	PHYS 1 Taken at UP		PHYS 1 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	59	2.10	3	2.89	-0.79	6	3.72	23	2.29	1.43
1	D	46	2.07	3	2.22	-0.16	10	3.63	12	2.58	1.05
2	C	812	2.33	101	1.94	0.39	39	3.41	370	2.51	0.90
2.33	C+	384	2.51	46	1.82	0.70	21	3.35	210	2.64	0.70
2.67	B-	484	2.63	57	1.80	0.83	19	3.53	323	2.74	0.79
3	B	716	2.83	94	2.33	0.50	33	3.53	422	2.93	0.60
3.33	B+	509	2.99	53	2.45	0.53	15	3.51	314	3.10	0.41
3.67	A-	383	3.22	64	2.43	0.79	11	3.24	330	3.27	-0.03
4	A	867	3.48	121	2.88	0.60	8	3.71	618	3.50	0.20
Total		4260	2.85	542	2.31	0.55	162	3.48	2622	3.02	0.46

H.C.= Head Count

Physics 2 performance at University Park and at the Commonwealth Campuses have similar overall trends. For the Physics 2 to Circuits comparison, Figure 2.5 shows that student performance in Circuits varies depending on location where students completed Physics 2. For Circuits courses offered at University Park, students who completed Physics 2 at a Commonwealth Campus earned Circuits grades 0.72 grade point lower than those who completed Physics 2 at University Park. For Circuits courses delivered at a Commonwealth Campus, students who also completed Physics 2 at a Commonwealth Campus performed 0.28 lower than those completed Physics 2 at the University Park.

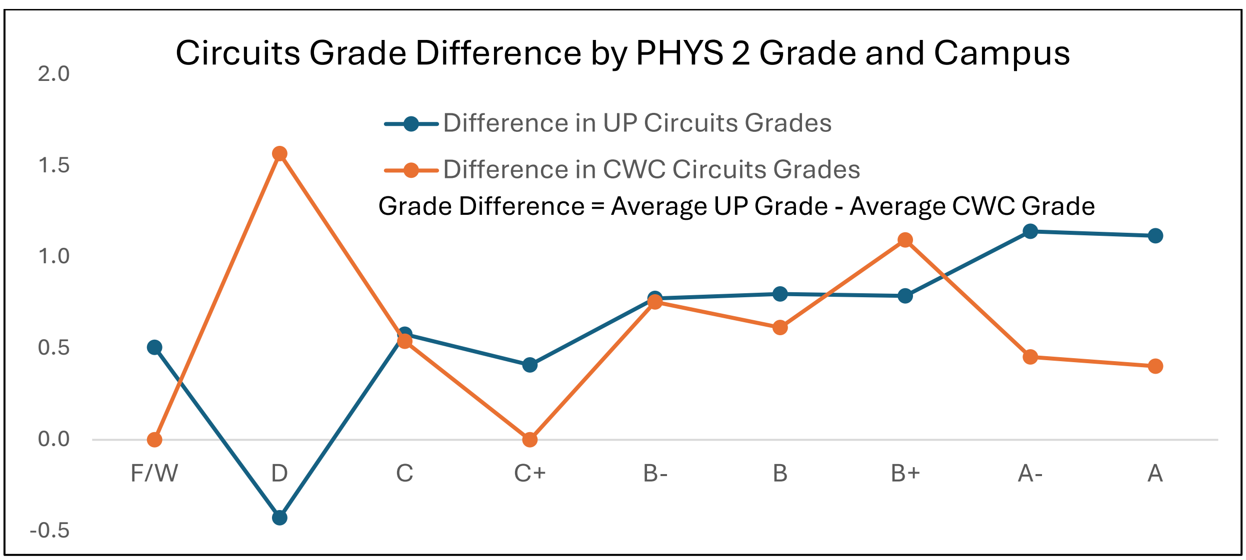

Figure 2.5: Difference in Circuits grades for both UP campus and Commonwealth campus delivery based on Physics 2 grades from University Park or Commonwealth Campus delivery

Table 6.5: Physics 2 to Circuits Performance

		Average Circuits Grade (Taken at UP)					Average Circuits Grade (Taken at CWC)				
PHYS 2 Grade Point	PHYS 2 Grade	PHYS 2 Taken at UP		PHYS 2 Taken at CWC		Difference in Grades	PHYS 2 Taken at UP		PHYS 2 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	19	1.63	8	1.13	0.51			3	1.78	
1	D	18	1.57	1	2.00	-0.43	2	3.00	10	1.43	1.57
2	C	252	2.01	63	1.43	0.58	5	2.73	98	2.19	0.54
2.33	C+	129	2.22	39	1.81	0.41			74	2.58	
2.67	B-	159	2.46	48	1.69	0.77	1	3.33	91	2.57	0.76
3	B	212	2.69	59	1.89	0.80	1	3.33	128	2.72	0.61
3.33	B+	133	3.01	58	2.22	0.79	1	4.00	97	2.91	1.09
3.67	A-	106	3.26	65	2.12	1.14	1	3.67	100	3.22	0.45
4	A	297	3.63	123	2.52	1.12	1	4.00	177	3.60	0.40
Total		1325	2.75	464	2.03	0.72	12	3.17	778	2.89	0.28

H.C.= Head Count

Another course that requires Physics 2 principles is the Measurements and Instrumentation course. This course supports a major with high student demand and a relatively high GPA requirement for entry into the major. Figure 2.6 presents results for this course as offered at the University Park and shows the grade difference based on where students completed Physics 2. Since Measurements and Instrumentation has only recently been offered at a Commonwealth Campus, there is no available data for students who took Physics 2 at University Park and subsequently completed the Measurements and Instrumentation course at a Commonwealth Campus. Because of this data gap, only a single plot is provided. The results show a very small average difference (-0.16 grade point) in the Measurements and Instrumentation course between students who completed Physics 2 at University Park and those who completed it at a Commonwealth Campus, suggesting minimal impact of Physics 2 instructional location on outcomes in this course.

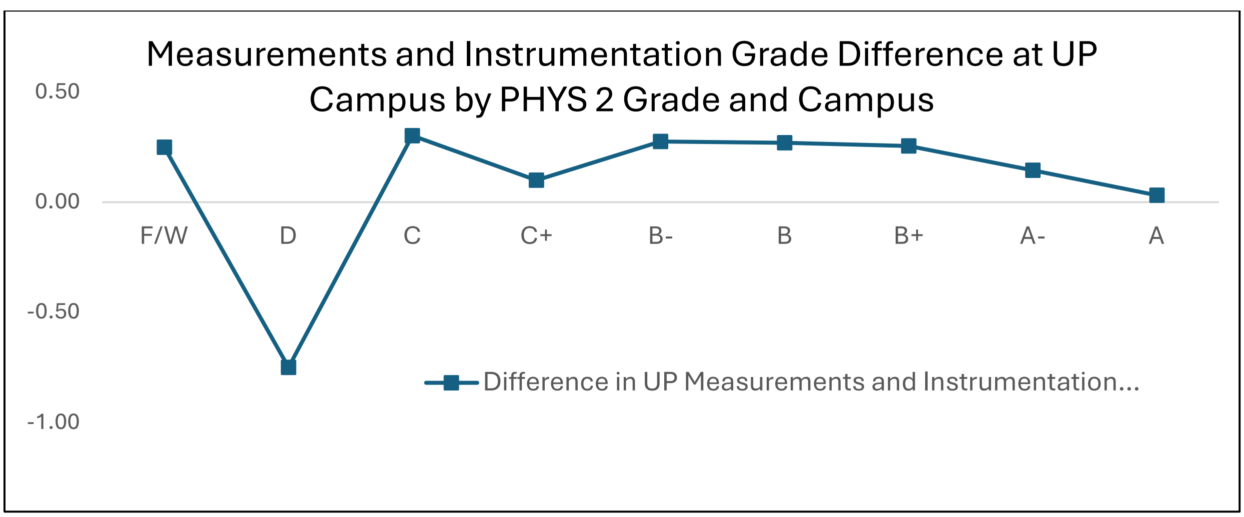

Figure 2.6: Difference in Measurements and Instrumentation grades for UP campus delivery based on Physics 2 grades from University Park or Commonwealth Campus delivery

Table 6.6: Physics 2 to Measurements and Instrumentation Performance

		Average Meas. and Inst. Grade (Taken at UP)					Average Meas. and Inst. Grade (Taken at CWC)				
PHYS 2 Grade Point	PHYS 2 Grade	PHYS 2 Taken at UP		PHYS 2 Taken at CWC		Difference in Grades	PHYS 2 Taken at UP		PHYS 2 Taken at CWC		Difference in Grades
		H.C.	Grade	H.C.	Grade		H.C.	Grade	H.C.	Grade	
0	F/W	7	4.00	4	3.75	0.25			1	3.00	
1	D	8	3.17	4	3.92	-0.75			1	3.33	
2	C	140	3.83	56	3.52	0.30			7	3.52	
2.33	C+	63	3.84	40	3.74	0.10			6	3.67	
2.67	B-	83	3.79	47	3.51	0.28			10	3.33	
3	B	123	3.80	77	3.53	0.27			5	3.80	
3.33	B+	105	3.82	60	3.56	0.25			4	3.75	
3.67	A-	87	3.87	97	3.73	0.15			4	3.33	
4	A	211	3.95	136	3.92	0.03			12	3.81	
Total		827	3.85	521	3.69	0.16			50	3.59	

H.C.= Head Count

Discussion

Student performance in foundational Physics courses appears to be a strong predictor of performance in future engineering courses. In almost every Physics grade grouping , there is a clear match between achievement in Physics and performance in the subsequent engineering course. In general, students who perform well in Physics 1 tend to perform well in Physics 2, Statics and Strengths of Materials, Statics, and Dynamics. Similarly, those who perform well in Physics 2 tend to do well in Circuits and Measurements and Instrumentation. This trend holds regardless of whether students complete the engineering coursework at University Park or a Commonwealth Campus. Notably, when Physics 1 or Physics 2 grades are low (D/F), students tend to perform better than expected in subsequent engineering courses relative to their Physics grade. However, these cases represent a relatively small number of students and may reflect unique contextual factors such as personal motivations related to GPA recovery, academic warning, or return from academic suspension.

Students enroll in Physics courses at a Commonwealth Campus for a variety of reasons before continuing into engineering coursework at University Park. Some students start their studies at a Commonwealth Campus, while others enroll in Commonwealth Campus offerings to accommodate scheduling constraints, including summer courses availability. Still, others might perceive courses at Commonwealth Campus courses as less demanding. In many instances, students performance in engineering courses offered at Commonwealth Campuses appear comparable to, and in some instances exceeds, that observed in similar courses offered at University Park. However, for the same engineering course taken at University Park, a consistent pattern emerges: students who completed Physics 1 or Physics 2 at University Park tend to perform quite a bit better than their peers who completed those Physics courses at the Commonwealth Campuses. .

Limitations and Future Work

The investigative team realizes there are opportunities to provide more resolution in each of the course pairings to provide more specific insight.

Limitations

- Limited knowledge of instructional practices at Commonwealth Campuses, including details about who is teaching Physics courses and how instructions is delivered outside of University Park. These may include variations in instructional modality (in-person, hybrid, or online delivery),instructor status (full time versus adjunct instructors), and academic term structure (standard semester versus compressed summer formats).

Limited ability to design and implement targeted interventions due to organizational structure. Physics courses are administered outside of the College of Engineering, and many students enrolled in these courses are likely engineering pre-majors who have not yet formally declared an engineering major. As a result, direct academic interventions coordinated through engineering programs may not reach students at the point when foundational Physics learning occurs.

Future Work

- Investigating the consistency of course content, assessment standards, and instructional rigor across all campus locations for both Physics and subsequent engineering courses.
- Improving alignment between Physics principles and engineering coursework. This includes deeper collaboration with Physics faculty, to reinforce the relevance of foundational Physics concepts for early engineering students. Ongoing efforts already include integrating engineering-based problems into Physics coursework.
- Exploring additional engineering courses beyond those examined here to identify whether similar patterns persist and to broaden the scope of this investigation. Expanding the course set may help to clarify whether observed trends are course-specific or indicative of broader curricular issues.
- Investigate first-year engineering students' readiness at University Park and Commonwealth Campuses to explore potential factors influencing students' performance in upper-level engineering courses.
- Assessing whether the observed differences between University Park and Commonwealth Campus students are statistically significant, and identifying factors associated with student outcomes.

Conclusion

The analysis of eight years of institutional data demonstrates a consistent and meaningful relationship between students' performance in foundational Physics courses and their outcomes in subsequent engineering courses. Across nearly all grade groupings, students who excel in Physics 1 and Physics 2 tend to perform well in follow-on courses such as Physics 2, Statics and Strengths of Materials, Statics, Dynamics, Circuits, and Measurements and Instrumentation.

These relationships hold regardless of the location where students complete their engineering coursework.

However, a clear pattern also emerges regarding course location. Students who complete foundational Physics coursework at University Park consistently tend to achieve higher grades in engineering courses offered at University Park than those students who complete Physics at a Commonwealth Campus. This pattern highlights the need for further investigation to identify how specific combination of pedagogical factors, such as differences in course delivery, instructional rigor, and alignment with engineering expectations, interact with student-related factors, including academic preparation and motivation, to influence students' performance in upper-level courses.

Future work should examine the consistency of course content, instructional practices, and academic rigor across campus locations; strengthen alignment between Physics and engineering curricula; and assess differences in student readiness. In particular, comparing first-year student preparation at University Park with that of first-year students at the Commonwealth Campuses may help to identify the underlying factors contributing to the observed performance disparities and inform targeted strategies for improvement.

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