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Data Analytics for Engineering Student Success and College Operations

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Data Analytics for Engineering Student Success and College Operations

As resource constraints have driven calls for more transparency and accountability in higher education, high demand disciplines like engineering are using data sets to justify decisions and shape strategic planning goals. However, engineering is also well-poised to employ data in visual and useful ways to analyze and synthesize years of data and trends. Serving a large undergraduate engineering student body across multiple campuses and encompassing multiple engineering disciplines, the Penn State University's College of Engineering can gain insights into the student population, faculty, and departments' needs. The college Data Analytics Team has become proficient at displaying data for decision makers and has become a resource and model for others in the university. Although each academic college has unique datasets that require their own dashboard builds, the Data Analytics Team's Power BI operations and products are deployable templates in a variety of contexts.

Several dashboards have already been packaged and shared with other colleges at the institution. Some dashboards have broad audiences, but most are tailored to specific people or roles. These roles have different needs and uses for data. Traditional dashboards feature static displays of information that hold data in arrangements like graphs and charts. Dashboards that are more sophisticated include interactive functionality to allow real-time monitoring. Dashboard users may toggle view options and filter information for specific subsets of data. Dashboards are powerful tools for tracking key performance indicators (KPIs). Selecting the appropriate dashboard design and identifying essential metrics enable the organization to effectively align behaviors, strategies, and measure success.

The goal of this work is to present how the use of the Power BI tool can enhance the effectiveness and efficiency of the college's undergraduate and graduate engineering programs through the development and implementation of comprehensive data analytics dashboards. This paper reports on a Data Analytics Team's efforts to assist the college's engineering programs in a variety of ways, including enrollment management, retention and graduation, identifying equity gaps, resource management, course scheduling, identifying high and low faculty teaching loads, and teaching assistant support. Several dashboards are presented with case studies, illustrating the data-driven decision-making process in the context of the engineering programs, such as student credit hours, enrollments, and retention. Additionally, the paper reviews data and operational challenges specific to these dashboards.

Introduction

Digital Transformation (DT) of data in higher education is becoming increasingly important in both academic research and educational practice. Educational institutions can empower leaders and managers to improve their performance and prioritize resources effectively by transforming data into actional information. This pivot toward integrating digital information into higher education administration has been motivated by several considerations to include emerging technological innovations and evolving labor market demands [1]-[2]. Communicating data effectively can be challenging in higher education, where typical business metrics such as revenue, cost, and hours, among others may not have analogs.

The term Business Intelligence (BI) has been used for nearly four decades, evolving from traditional industries into higher education. It is a technology driven process of gathering and analyzing data that is organized and portrayed as actionable information to help leaders and managers make informed decisions [3]. BI can translate complex, multifaceted data into useful information and meaningful understanding.

The main function of a BI dashboard is to support leaders and managers in decision making [4]. Dashboards for organizations, whether businesses or higher education institutions, function similarly to dashboards in automobiles. Just as a car's dashboard provides drivers with crucial information for safe and efficient operation, organizational dashboards offer users a quick and concise overview of Key Performance Indicators (KPI) and scorecards. They provide a system to simplify and connect data at multiple levels of an organization. By aggregating and visualizing data in a user-friendly manner, dashboards can uncover interesting information, including trends, patterns and associations, which can be sourced for predictive analytics and informed decision-making. The key capabilities of dashboards include data visualization with graphs and maps, filters, and drill-down features.

BI dashboards allow academic organization leaders to share information with other faculty and staff leaders using visual instruments. These administrators need accurate and appropriate information to make effective decisions. However, the main challenge lies in analysis and prediction. One way to understand the data and the key material is through visualization techniques. With the abundance of electronic information available, dashboards and data visualization transform the material into dependable information. In higher education, information is necessary to adapt to changing student trends, preparedness, and other factors. Educational institutions that use BI dashboards can identify opportunities to improve the efficiency and effectiveness of their operations. Administrator questions often drive dashboard design and improvement with inquiries, serving as indicators of current strategic operational priorities.

This research contributes to the expanding role of BI dashboards in higher education by examining their practical applications. This study is important as it provides perceptions and insights from both BI developers as well as higher education professionals who use BI for college decision-making. Penn State University uses Power BI from Microsoft to create its dashboards. This paper will describe part of the suite of dashboards developed and how they can be used for effective decision-making.

Student Dashboards

Published Dashboards are dynamic visualizations that are updated periodically - whether weekly, semi-annually, or as needed- and continually receive enhancements and refinement based on users' feedback and evolving requirements. The Data Analytics Team constantly updates the Dashboards and meets with users to determine their needs. The goal is to use the Dashboards to answer the users' most frequently asked questions effectively, providing timely and actionable information that supports decision-making.

The College of Engineering (CoE) maintains several groups of Dashboards to serve communities of users. These include Research Dashboards, Finance Dashboards, and Student Data Dashboards. The Data Analytics Team can also create Dashboards for specific users on a case-by-case basis, such as specific course enrollments. Some of the current Student Data Dashboards include the following.

- **Current Term Enrollment** - Term enrollment of CoE students of the current Spring or Fall semester. State campus undergraduate and World Campus graduate students are included.
- **Current Course Enrollment** – CoE course enrollment of the current Spring or Fall semester. All (CoE or non-CoE) students enrolled in CoE courses are included.
- **10 Years Term Enrollment** - CoE term enrollment of the most recent 10 years.
- **Class Enrollment** - Class enrollment data since AY2016-17 is used to calculate the unofficial CoE Student Credit Hour, which serves as a metric for to assessing teaching load.
- **Official Enrollment** - CoE official enrollment of the most recent 10 years.
- **Degrees Awarded** - CoE official degrees awarded data of the most recent 10 years.
- **UG Retention & Graduation Rates** - CoE undergraduate freshman cohort retention and graduation rates.
- **Undergraduate Admissions** - Year-over-year CoE undergraduate admissions data.
- **Graduate Admissions** - Year-over-year CoE graduate admissions data.
- **U.S. News Best Engineering Grad Overall Rankings** - U.S. News Best Engineering Schools Graduate Overall Rankings. In-department analysis of ranking criteria/indicators, college performance over time, benchmarking with peers.
- **Class Meeting Pattern** - Class meeting patterns of CoE classes for the upcoming fall or spring classes.
- **Official Student Credit Hours** - University's official student credit hour data for the College of Engineering.

Insights and Impact on underrepresented students and women

The College has a long history of supporting students from groups historically underrepresented in engineering, helping them navigate through barriers to opportunity, access, and inclusion in the academic community. These efforts have largely focused on support networks that build community and academic support programs to address areas where students are either left out of opportunities or may find themselves underprepared for some elements of the engineering curriculum. Therefore, it is equally important to ensure that changes to curricula or other requirements do not disproportionally disadvantage underrepresented students. Dashboards can easily transform historical data into tangible information, allowing for thorough analysis of the impact on underrepresented students and women in engineering.

Many of the CoE Dashboards have demographic data to include in analysis. Some demographics include:

- Gender
- Race/Ethnicity
    - Under-represented Minorities (URM)
        - African American (BLK)
        - Hispanic (HSP)
    - Non-URM Domestic
    - International (INT)
- First-Generation (Domestic)
- Adult Learner
- Starting Campus (Main vs. Satellite)
- Program Participants (WEP, MEP, Summer Bridge, Study Abroad…)

Case Study 1: Using Undergraduate Retention Dashboard to Gain Insights on Intersectionality as an Indicator of Engineering Student Retention

When studying risk factors in student success, traditional analyses usually use one dimensional variables, such as gender, race/ethnicity, first-generation status, etc. To make it more challenging for those working within an academic unit, most retention dashboards are developed by the university's central institutional research offices, which rarely provide data on students' retention within individual college.

The College of Engineering's **UG Retention & Graduation Rates** dashboard is a dynamic dashboard. The college can track any sub-group of students by providing a roster of students. It provides five scopes of retention data, including retention within the college at the main campus, within the college of all campuses, within engineering majors, within STEM majors, and within the entire university. It has become a powerful tool to identify retention gaps from both the lens of intersectionality of student identity and comparison between two scopes of retention (within college vs. within the entire university).

Six visuals (Figures 1-6) are provided below to illustrate the iteration process followed when identifying retention gaps. The six horizontal bars for each group of students represent retention rates from Year 1 to Year 6 of the first-year cohort who started from the College of Engineering on the main campus. Data used in this case study is the 6-Year Retention Rate. It is visually very easy to identify which groups have low retention rates. In addition, academic leaders can also identify the year in which a sharp decline happens in retention rate.

The very left in each visual is the comparison group. The numbers in color (right below the group name in each box) indicate that the 6-Year retention rate of that group of students is *n* percentage points (pp) higher (in green) or lower (in red) than the comparison group on the left.

Insight 1.1: When looking at university-wide retention in a single dimension of student identity, African American is the lowest, with 17 pp lower, whereas women is 4 pp higher (Figure 1).

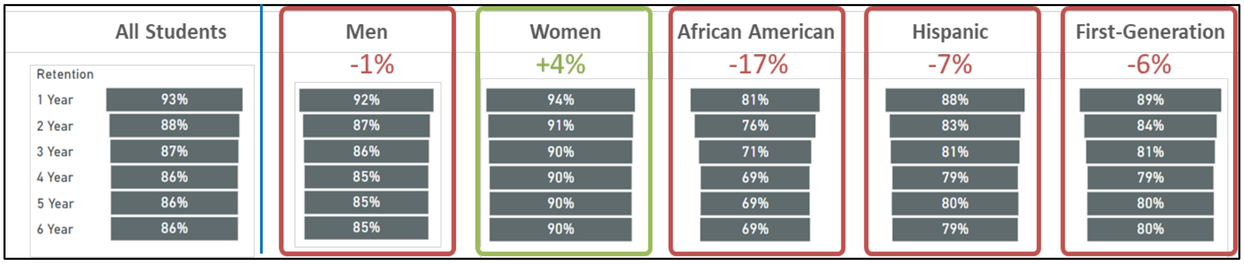


Figure 1: University-wide Retention

Insight 1.2: However, when looking at College-wide retention, the gap for African American is enlarged to 28 pp, and women lost the advantage (Figure 2).

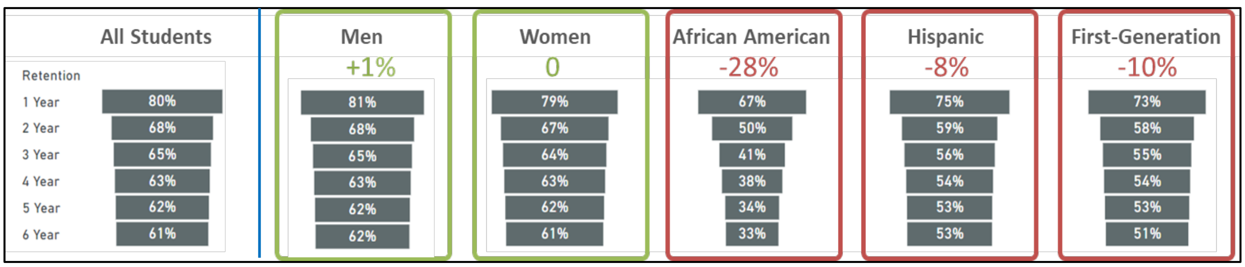


Figure 2: College-wide Retention

Insight 2.1: A second layer of identity is now added based on first-generation status. When looking at university-wide retention with two dimensions, first-generation African American shows a gap of 25 pp, followed by first-generation Hispanic with a gap of 18 pp compared with non-first-generation peers (Figure 3).

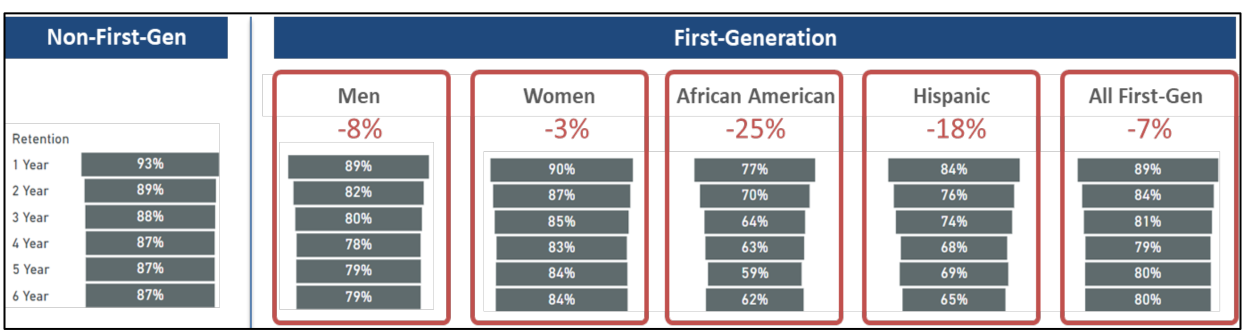


Figure 3: University-wide Retention and First Generation

Insight 2.2: In comparison, the College-wide retention data shows a gap of 44 pp for first-generation African American, followed by first-generation Hispanic with a gap of 25 pp (Figure 4).

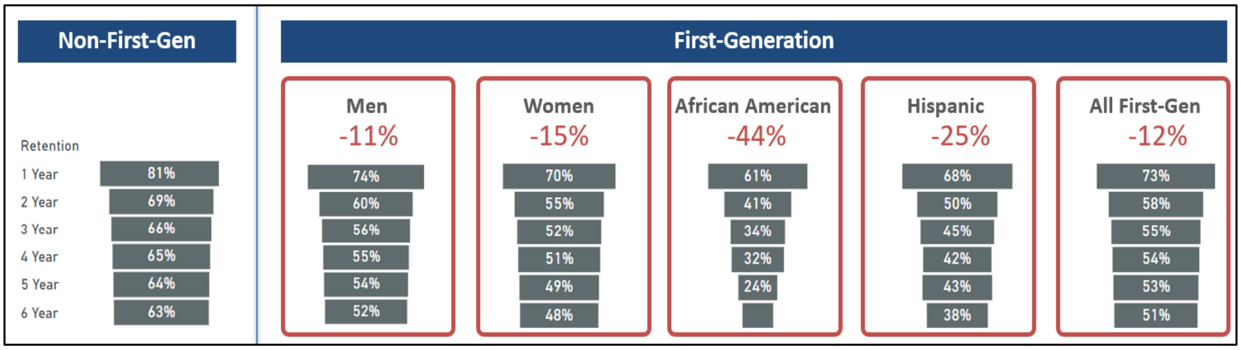


Figure 4: College-wide Retention and First Generation

Insight 3.1: Gender is then added as the third dimension to this data exploration. When looking at university-wide retention with three dimensions, first-gen female African American saw a gap of 31 pp compared with their non-first-generation peers, followed by first-generation male Hispanic with a gap of 24 pp (Figure 5).

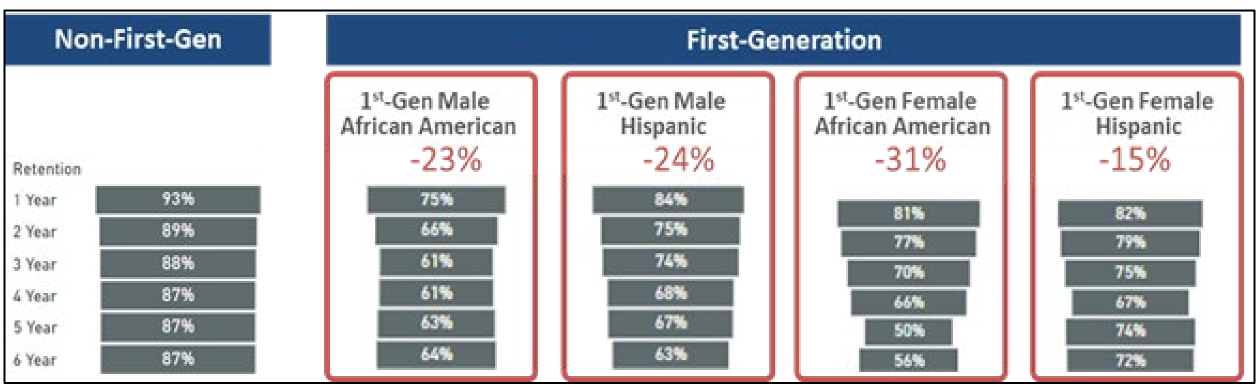


Figure 5: University-wide Retention, First Generation, and Gender

Insight 3.2: The College-wide retention data, when viewed with three-dimensions of intersecting identity, shows a gap of astonishing 50 pp for first-gen female African American students, followed by first-gen male Hispanic with a gap of 42 pp (Figure 6).

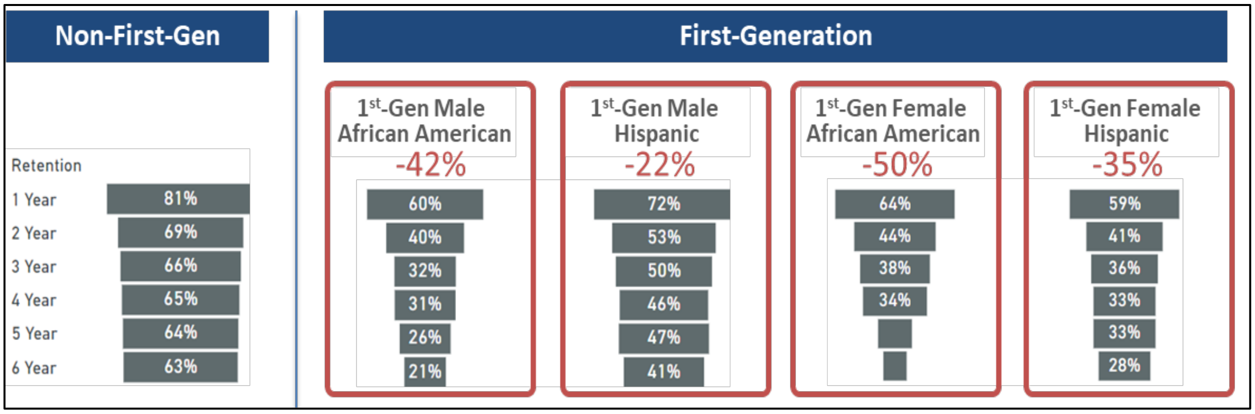


Figure 6: College-wide Retention, First Generation, and Gender

Case Study 1 Summary:

This case study demonstrates the value of using dynamic dashboards to explore student retention gaps from an intersectional perspective.

1. Layered Identity Analysis: By adding multiple identity layers to the analysis (e.g., race/ethnicity, gender, first-generation status), significant disparities in retention rates are highlighted that might otherwise be overlook in single-dimension analyses. The iterative process of adding dimensions (e.g., race/ethnicity, first-generation status, and gender) reveals that retention gaps become more pronounced when viewed within the College of Engineering compared to the university as a whole.
2. Multi-Scope Visualization: The ability to visualize data across multiple scopes of retention—university-wide, within STEM, within engineering majors, and within the college—is critical for pinpointing where interventions might be most needed, even if not fully shown in the paper.
3. Yearly Retention Trends: The dashboard allows for the identification of specific years where retention sharply declines, informing to the timing for implementing support programs.
4. Targeted Interventions: Highlighting specific retention gaps within a particular retention scope and year provides concrete data to guide targeted interventions. For example, when looking at 6-Year retention rate, there is a 50 percentage-point gap for first-generation female African American students within the College of Engineering. The sharpest decline is observed between Year 1 and Year 2.

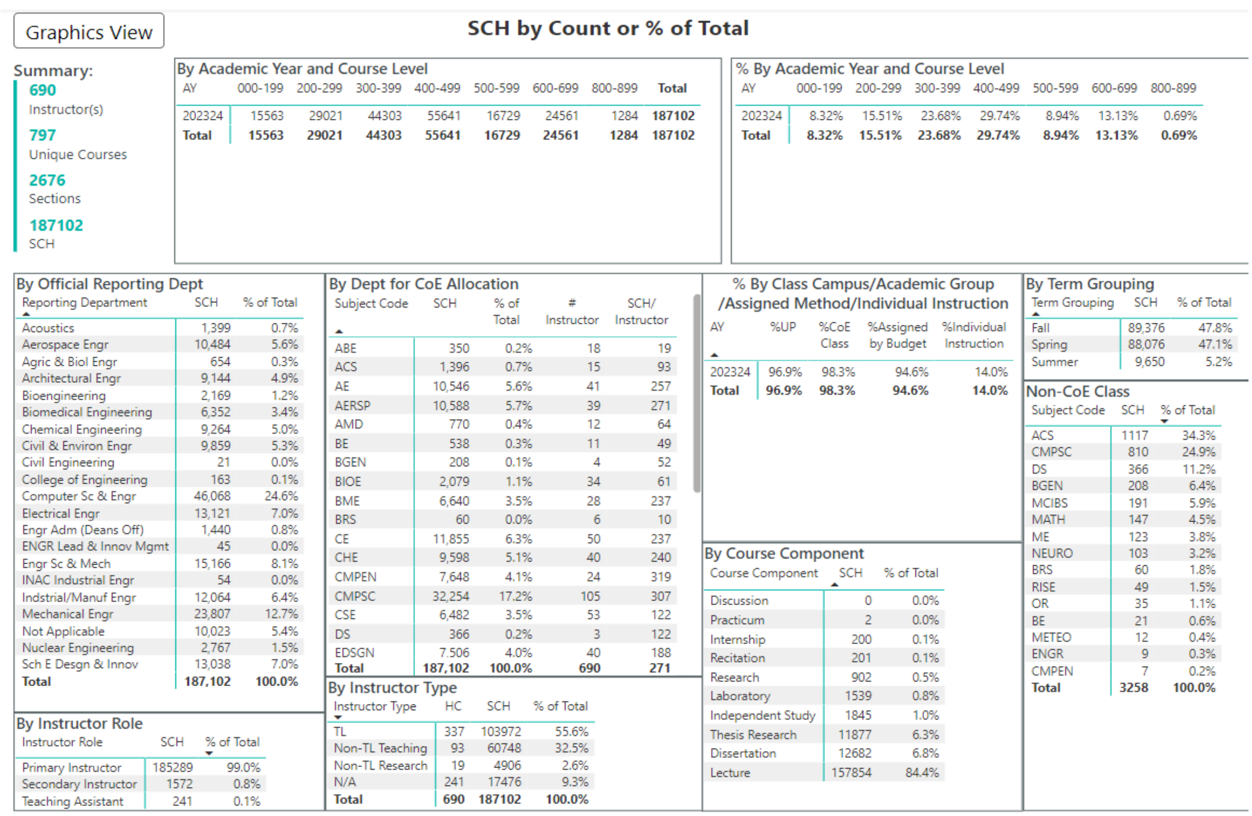
The demographic identifiers used in this case study are only a very small part of the rich and deep data that powers the dashboard. For example, the dashboard has 37 dimensions (or filters) including student pre-college preparation, intended majors, early academic performance, etc.; five retention scopes as explained in the beginning of this case study; and outcome (such as grade and number of attempts) of eight entrance-to-major courses at three time periods (after the first fall semester, after the first year, after the second year). As new programs are being offered, participants in these programs are flagged. Program directors use this dashboard to track student success and evaluate the impact of their program as well as to identify outcome gaps among different student groups.

Lists of at-risk freshman students are shared, before the start of their first spring semester, with the College's advising team. The advising center created targeted outreach messages to encourage these students to see their advisor, promoting an early engagement and conversation with the advisor.

Overall, the data and analysis from this dashboard allowed college leaders to propose and support specific interventions, such as additional tutoring for identified first and second year courses and encouraging participation in organizations like Women in Engineering and Multicultural Engineering Programs to foster a sense of belonging and inclusion such as.

Case Study 2: Student Credit Hours

The Student Credit Hours (SCH) Dashboard offers valuable insights, featuring Drill Down options that enable college administration to analyze trends within individual departments. Figure 7 below illustrates data for one academic year, showing department and program totals. The Dashboard also includes information of the type of instruction (lecture, lab, research, etc.) and the distribution of credit hours by instructor type, differentiating between tenure track and non-tenure track faculty.



Graphics View

SCH by Count or % of Total

Summary:
690 Instructor(s)
797 Unique Courses
2676 Sections
187102 SCH

By Academic Year and Course Level

AY	000-199	200-299	300-399	400-499	500-599	600-699	800-899	Total
202324	15563	29021	44303	55641	16729	24561	1284	187102
Total	**15563**	**29021**	**44303**	**55641**	**16729**	**24561**	**1284**	**187102**

% By Academic Year and Course Level

AY	000-199	200-299	300-399	400-499	500-599	600-699	800-899
202324	8.32%	15.51%	23.68%	29.74%	8.94%	13.13%	0.69%
Total	**8.32%**	**15.51%**	**23.68%**	**29.74%**	**8.94%**	**13.13%**	**0.69%**

By Official Reporting Dept

Reporting Department	SCH	% of Total
Acoustics	1,399	0.7%
Aerospace Engr	10,484	5.6%
Agric & Biol Engr	654	0.3%
Architectural Engr	9,144	4.9%
Bioengineering	2,169	1.2%
Biomedical Engineering	6,352	3.4%
Chemical Engineering	9,264	5.0%
Civil & Environ Engr	9,859	5.3%
Civil Engineering	21	0.0%
College of Engineering	163	0.1%
Computer Sc & Engr	46,068	24.6%
Electrical Engr	13,121	7.0%
Engr Adm (Deans Off)	1,440	0.8%
ENGR Lead & Innov Mgmt	45	0.0%
Engr Sc & Mech	15,166	8.1%
INAC Industrial Engr	54	0.0%
Indstrial/Manuf Engr	12,064	6.4%
Mechanical Engr	23,807	12.7%
Not Applicable	10,023	5.4%
Nuclear Engineering	2,767	1.5%
Sch E Desgn & Innov	13,038	7.0%
Total	**187,102**	**100.0%**

By Instructor Role

Instructor Role	SCH	% of Total
Primary Instructor	185289	99.0%
Secondary Instructor	1572	0.8%
Teaching Assistant	241	0.1%

By Dept for CoE Allocation

Subject Code	SCH	% of Total	# Instructor	SCH/ Instructor
ABE	350	0.2%	18	19
ACS	1,396	0.7%	15	93
AE	10,546	5.6%	41	257
AERSP	10,588	5.7%	39	271
AMD	770	0.4%	12	64
BE	538	0.3%	11	49
BGEN	208	0.1%	4	52
BIOE	2,079	1.1%	34	61
BME	6,640	3.5%	28	237
BRS	60	0.0%	6	10
CE	11,855	6.3%	50	237
CHE	9,598	5.1%	40	240
CMPEN	7,648	4.1%	24	319
CMPSC	32,254	17.2%	105	307
CSE	6,482	3.5%	53	122
DS	366	0.2%	3	122
EDSGN	7.506	4.0%	40	188
Total	**187,102**	**100.0%**	**690**	**271**

By Instructor Type

Instructor Type	HC	SCH	% of Total
TL	337	103972	55.6%
Non-TL Teaching	93	60748	32.5%
Non-TL Research	19	4906	2.6%
N/A	241	17476	9.3%
Total	**690**	**187102**	**100.0%**

% By Class Campus/Academic Group /Assigned Method/Individual Instruction

AY	%UP	%CoE Class	%Assigned by Budget	%Individual Instruction
202324	96.9%	98.3%	94.6%	14.0%
Total	**96.9%**	**98.3%**	**94.6%**	**14.0%**

By Course Component

Course Component	SCH	% of Total
Discussion	0	0.0%
Practicum	2	0.0%
Internship	200	0.1%
Recitation	201	0.1%
Research	902	0.5%
Laboratory	1539	0.8%
Independent Study	1845	1.0%
Thesis Research	11877	6.3%
Dissertation	12682	6.8%
Lecture	157854	84.4%

By Term Grouping

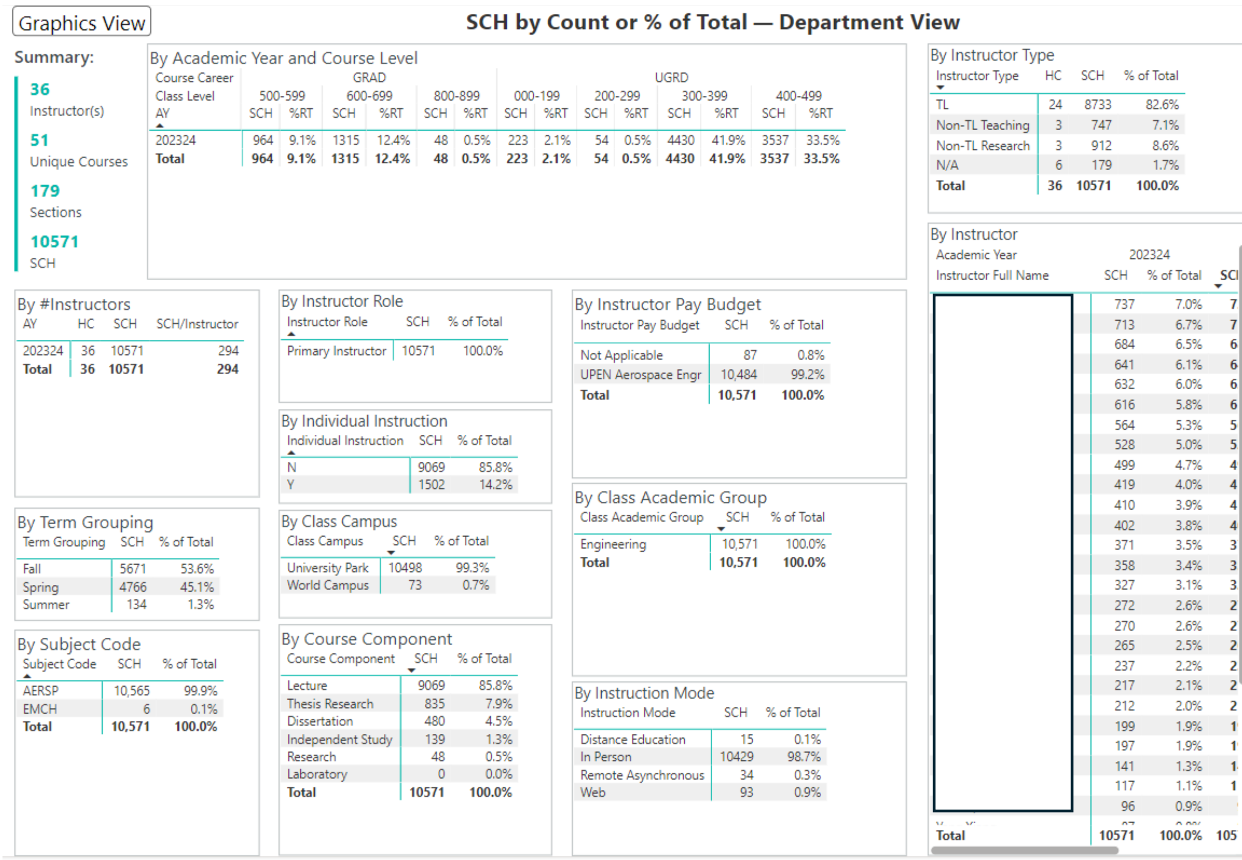
Term Grouping	SCH	% of Total
Fall	89,376	47.8%
Spring	88,076	47.1%
Summer	9,650	5.2%

Non-CoE Class

Subject Code	SCH	% of Total
ACS	1117	34.3%
CMPSC	810	24.9%
DS	366	11.2%
BGEN	208	6.4%
MCIBS	191	5.9%
MATH	147	4.5%
ME	123	3.8%
NEURO	103	3.2%
BRS	60	1.8%
RISE	49	1.5%
OR	35	1.1%
BE	21	0.6%
METEO	12	0.4%
ENGR	9	0.3%
CMPEN	7	0.2%
Total	**3258**	**100.0%**

Figure 7: Student Credit Hours (SCH) Per Department

Figure 8 below shows a Drill Down to a particular department, allowing leadership to analyze student credit hours generated by each faculty member, categorized by delivery mode (resident or remote). The Student Credit Hour Dashboards have been used by several departments to justify faculty hires and assist the college in its overall faculty hiring strategy, including the consideration of dual appointments where possible.


Graphics View

SCH by Count or % of Total — Department View

Summary: 36 Instructor(s); 51 Unique Courses; 179 Sections; 10571 SCH

By Academic Year and Course Level

Course Career	GRAD						UGRD							
Class Level	500-599		600-699		800-899		000-199		200-299		300-399		400-499	
AY	SCH	%RT	SCH	%RT	SCH	%RT	SCH	%RT	SCH	%RT	SCH	%RT	SCH	%RT
202324	964	9.1%	1315	12.4%	48	0.5%	223	2.1%	54	0.5%	4430	41.9%	3537	33.5%
Total	**964**	**9.1%**	**1315**	**12.4%**	**48**	**0.5%**	**223**	**2.1%**	**54**	**0.5%**	**4430**	**41.9%**	**3537**	**33.5%**

By Instructor Type

Instructor Type	HC	SCH	% of Total
TL	24	8733	82.6%
Non-TL Teaching	3	747	7.1%
Non-TL Research	3	912	8.6%
N/A	6	179	1.7%
Total	**36**	**10571**	**100.0%**

By #Instructors

AY	HC	SCH	SCH/Instructor
202324	36	10571	294
Total	**36**	**10571**	**294**

By Instructor Role

Instructor Role	SCH	% of Total
Primary Instructor	10571	100.0%

By Instructor Pay Budget

Instructor Pay Budget	SCH	% of Total
Not Applicable	87	0.8%
UPEN Aerospace Engr	10,484	99.2%
Total	**10,571**	**100.0%**

By Individual Instruction

Individual Instruction	SCH	% of Total
N	9069	85.8%
Y	1502	14.2%

By Term Grouping

Term Grouping	SCH	% of Total
Fall	5671	53.6%
Spring	4766	45.1%
Summer	134	1.3%

By Class Campus

Class Campus	SCH	% of Total
University Park	10498	99.3%
World Campus	73	0.7%

By Class Academic Group

Class Academic Group	SCH	% of Total
Engineering	10,571	100.0%
Total	**10,571**	**100.0%**

By Subject Code

Subject Code	SCH	% of Total
AERSP	10,565	99.9%
EMCH	6	0.1%
Total	**10,571**	**100.0%**

By Course Component

Course Component	SCH	% of Total
Lecture	9069	85.8%
Thesis Research	835	7.9%
Dissertation	480	4.5%
Independent Study	139	1.3%
Research	48	0.5%
Laboratory	0	0.0%
Total	**10571**	**100.0%**

By Instruction Mode

Instruction Mode	SCH	% of Total
Distance Education	15	0.1%
In Person	10429	98.7%
Remote Asynchronous	34	0.3%
Web	93	0.9%

By Instructor

Academic Year	202324	
Instructor Full Name	SCH	% of Total
	737	7.0%
	713	6.7%
	684	6.5%
	641	6.1%
	632	6.0%
	616	5.8%
	564	5.3%
	528	5.0%
	499	4.7%
	419	4.0%
	410	3.9%
	402	3.8%
	371	3.5%
	358	3.4%
	327	3.1%
	272	2.6%
	270	2.6%
	265	2.5%
	237	2.2%
	217	2.1%
	212	2.0%
	199	1.9%
	197	1.9%
	141	1.3%
	117	1.1%
	96	0.9%
Total	**10571**	**100.0%**

Figure 8: Student Credit Hour (SCH) Distribution by Individual Instructor

The SCH Dashboard has enabled college leadership to develop more equitable hiring practices, allocate teaching assistants to programs with higher undergraduate teaching loads, and identify opportunities for more balanced teaching loads across programs with varying needs or capacity to teach in other similar programs. At the same time, department leadership and committees have used the data to help faculty reflect on their balance between teaching and research.

Case Study 3: Junior Course Enrollment

The following example shows how data and the Dashboards can be used to predict third year course enrollments for the Aerospace Engineering program. Many engineering curricula experience a spike in program specific courses during the third year since many students take many foundational courses in math, science, and general education during their first two years. Engineering programs have very few first and second year courses in their curricula.

The College continues to experience robust interest in its majors. In the last few years, the applications from prospectives students indicating a preference for an engineering major have averaged over 20,000 annually, with actual acceptance (enrollments) exceeding 2,000 new students. Some majors have enrollment controls, such as minimum GPAs requirements, in response to high student demand. The impact of this practice is felt across the college, as students who are unable to enroll in their first-choice major often seek alternatives within other engineering disciplines, leading to increased enrollment in those areas. Student requests are typically supported based on enrollment controls in other engineering majors and observed patterns in entrance-to-major requests. Further, the college continues to make significant investments in faculty recruitment to increase instructional capacity in order to provide access for more students across all engineering majors. This effort is reflected in the adjustment of entrance-to-major GPAs for some of the controlled majors, relative to previous requirements.

The Data Analytics Team worked with departments to identify specific instructional pressures in the third year, including prerequisites and corequisites, to understand the complexities and dependencies. Additionally, the college prioritized access to the majors as a principal goal.

In 2020, an analysis of enrollment trends revealed that the number of students entering the Aerospace major had exceeded the stated capacity of 100 for the years 2018-2020, averaging 126 students annually. The application of enrollment controls during these years has successfully reduced and stabilized enrollment numbers. By 2021, with entrance-to-major numbers stabilizing at around 126 students with a GPA requirement of 3.1, the department made some structural changes and adjusted its capacity to 125.

The number of students indicating Aerospace as their intended major remained fairly consistent, with a noticeable increase in the class entering in the Fall 2020 cohort. Given the stabilization at this higher enrollment level, and the department's efforts to expand capacity, the 3.1 GPA requirement was retained for several years. However, by 2022, with further restructuring and additional faculty hires, the department determined it had a capacity of 190 students each year. As part of the entrance-to-major requirement, the department changed its GPA requirement to 2.9 from 3.1. At that time, the number of new students indicating Aerospace as an intended major had remained stable. However, the program's recent surge in popularity and increased accessibility have caused the department to reassess its teaching capacity to ensure it can effectively meet the rising demand.

Alternative programs and locations are listed on the College's website to guide students to other available engineering programs.

Methodology

This section outlines the process how available data can be used to make informed decisions for teaching capacity and requirements for a particular program. It outlines a process to predict how many students might need a seat in third-year courses in fall 2023 and spring 2024. The Data Analytics Team, along with department /program leadership, analyzed ten key trends including:

term enrollment, class enrollments, and paid accepts. Although not every trend is used in the prediction of class enrollments, each was thoroughly examined to ensure a comprehensive analysis and minimize the risk of overlooking factors. Table 1 is a partial list of the trends and their rationale.

TABLE 1: Partial List of Trends and Descriptions

Trend Analyze	Trend Description	Rationale	Used in Prediction	Years of Data Analyzed	Data Source	Data Type
A	Which junior course(s) offered by your department have the highest course enrollment. Fall and Spring trends were looked at seperately. Late drops and withdrawals are included.	We mostly used the list of courses you suggested. This process ensures that we don't leave out any highly enrolled courses in case there is increased enrollment in certain courses in recent years.	Yes	6 academic years	Student Credit Hour dashboard	Class Enrollment
B	Distribution by major and year at Penn State of those enrolled in the course selected from Trend A	To identify trend in the % of students enrolled in the course both by major and year at Penn State. If a course is mostly taken by 3rd-year students in your major, which is the case in most departments, it's relatively simple in the prediction. Otherwise, other factors are taken into consideration.	Yes	6 academic years	Student Credit Hour dashboard	Class Enrollment

Steps:

I. Identify the course to analyze
II. Understand course enrollment pattern
III. Understand term enrollment pattern by Yr at the college / university (2Y ago → 1Y ago → current semester)
IV. Understand the major's percentage of total College of Engineering enrollments
V. Understand patterns if the course is mostly enrolled by those who are not juniors in the major (e.g. 2nd-Yr or 4th-Yr in the major, or 3rd-Yr in other majors), or with high repeat rate.

Trends Analyzed:

I. Identify the course to analyze
   1. Which 3rd-Yr course(s) offered by the department have the highest course enrollment? (A)

II. Understand course enrollment pattern:
   2. By what major, in which year (B)
   3. Is the course mostly enrolled by 3rd-Yr students in the major? Are patterns the same in fall versus the spring semester? (C)

III. Understand term enrollment pattern by year (Yr) at the university: (2Y ago → 1Y ago → current semester)
   4. Ratio = current 4th-Yr in the major and last year's 3rd-Yr in the major (D)
   5. Ratio = current 3rd-Yr in the major and last year's 2nd-Yr (F)

6. Ratio = last year's 2nd-Yr and freshman 2Ys ago (E)

IV. Understand the major's % of total enrollments in the College of Engineering:

7. % of 3rd-Yr students in the major of total third year (G)
8. % of the major as intended plan of total paid accepts last year (H)

V. Understand patterns if the course is mostly enrolled by those who are not 3rd-Yr in the major (e.g. 2nd-Yr or 4th-Yr in the major, or 3rd-Yr in other majors), or with high repeat rate.

9. Ratio = cumulative class enrollment of 3rd-Yr students in the major / head count of 3rd-Yr students in the major (I)
10. Ratio = cumulative class enrollment of 4th-Yr students in the major / head count of 3rd-Yr in the major last year (J)

Clarification of the Ten Factors:

A. Which 3rd-year course(s) offered by the department have the highest course enrollment. Fall and Spring trends were looked at separately. Late drops and withdrawals are included.

B. Distribution by major and year at the university of those enrolled in the course selected from Trend A.

C. % 3rd-year students in the major who took the course of total 3rd-year students in the major. Fall and Spring trends were looked at separately.

D. Ratio in term enrollment between 4th-year students in the major and 3rd-year students in the major the previous fall. For example, 4th-year AERSP in fall 2019 is 138, and 3rd-year AERSP in fall 2018 is 139, so the ratio = 138/139 ≈ 1

E. Ratio between 2nd-year university engineering undergraduates one year ago and 1st-year university engineering undergraduates two years ago

F. Ratio between 3rd-year students in the major and 2nd-year engineering undergraduates one year ago

G. % 3rd-year students in the major of total engineering 3rd-year students.

H. Distribution of first year paid accepts of past fall by intended plan (at the time of application).

I. Ratio between cumulative class enrollment of 3rd-year students in the major and total 3rd-year students in the major. The class enrollment is not the unique head count. For example, if a student retakes the course, it counts as "2" in the class enrollment.

J. Ratio between cumulative class enrollment of 4th-year students in the major and total 3rd-year students in the major one year ago. The class enrollment is not the unique head count. For example, if a student retakes the course, it counts as "2" in the class enrollment.

Table 2 below presents data on the total number and percentage of students who paid deposits and accepted an offer of admission to the College.

TABLE 2: College of Engineering Paid Accepts

Intended Plan	UP Paid Accepts by Head Count						UP Paid Accept by % of Total						
	SUFA18	SUFA19	SUFA20	SUFA21	SUFA22	Trendline	SUFA18	SUFA19	SUFA20	SUFA21	SUFA22	Trendline	PP Diff.
AE_BAE	50	58	62	88	74		2.9%	3.2%	3.5%	4.3%	3.4%		0.5
AERSP_BS	146	130	180	203	209		8.6%	7.2%	10.1%	9.9%	9.7%		1.1
BE_BS	18	11	15	16	17		1.1%	0.6%	0.8%	0.8%	0.8%		-0.3
BME_BS	155	175	168	159	159		9.1%	9.7%	9.5%	7.7%	7.4%		-1.7
CE_BS	98	104	113	107	97		5.8%	5.8%	6.4%	5.2%	4.5%		-1.3
CHE_BS	140	122	126	114	92		8.2%	6.8%	7.1%	5.6%	4.3%		-4.0
CMPEN_BS	93	113	78	94	141		5.5%	6.3%	4.4%	4.6%	6.5%		1.1
CMPSC_BS	277	376	353	493	623		16.3%	20.9%	19.9%	24.0%	28.8%		12.6
DTSCE_BS	1	10	11	9	21		0.1%	0.6%	0.6%	0.4%	1.0%		0.9
EE_BS	85	77	62	75	80		5.0%	4.3%	3.5%	3.7%	3.7%		-1.3
ESC_BS	6	11	11	12	11		0.4%	0.6%	0.6%	0.6%	0.5%		0.2
IE_BS	54	44	39	57	46		3.2%	2.4%	2.2%	2.8%	2.1%		-1.0
ME_BS	290	256	264	311	298		17.0%	14.2%	14.9%	15.2%	13.8%		-3.2
N/A	261	287	273	297	279		15.3%	15.9%	15.4%	14.5%	12.9%		-2.4
Non-COE Major	4	4					0.2%	0.2%	0.0%	0.0%	0.0%		-0.2
NUCE_BS	24	24	21	17	14		1.4%	1.3%	1.2%	0.8%	0.6%		-0.8
Total	**1702**	**1802**	**1776**	**2052**	**2161**		100%	100%	100%	100%	100%		

Four distinct methods were used to predict enrollments. While not all the methods utilized every factor described above, each was thoroughly investigated to ensure a comprehensive analysis and to identify any potential cause-and-effect relationship. Detailed descriptions of the four methods are provided below:

- Method 1: This straight-forward method focuses on predicting fall class enrollment. It is particularly effective when the majority of students taking the course are 3rd-year students from the same department. It has simplicity and high reliability.
- Method 2: This method builds upon the prediction of FALL class enrollment, as explained in Method 1, while incorporating data from class enrollment in all previous semesters. It is particularly recommended when the most students enrolled in the course are 3rd-year students from the same department, AND most class enrollments occur during the FALL semester.
- Method 3: Similar to Method 1, this method primarily focuses on predicting SPRING cand includes data from all previous semesters. It is particularly recommended when most students enrolled in the course are 3rd-year students from the same department AND when most of the class enrollment occurs in the SPRING semester.
- Method 4: This method considers class enrollment from all semesters equally, making it ideal for situations where the majority of students taking the course are NOT 3rd-year students from the same department OR when enrollment numbers are relatively balanced between the fall and spring semesters.

Predicted enrollment varies when using different methods. A range of predicted enrollment is provided for each course for fall 2023 and/or spring 2024 so the program can assess their teaching capacity and enact or adjust its entrance-to-major requirements. The Data Analytics Team developed the flow chart presented in Figure 9 to guide the selection of the most suitable method based on the semester in which the course is offered.

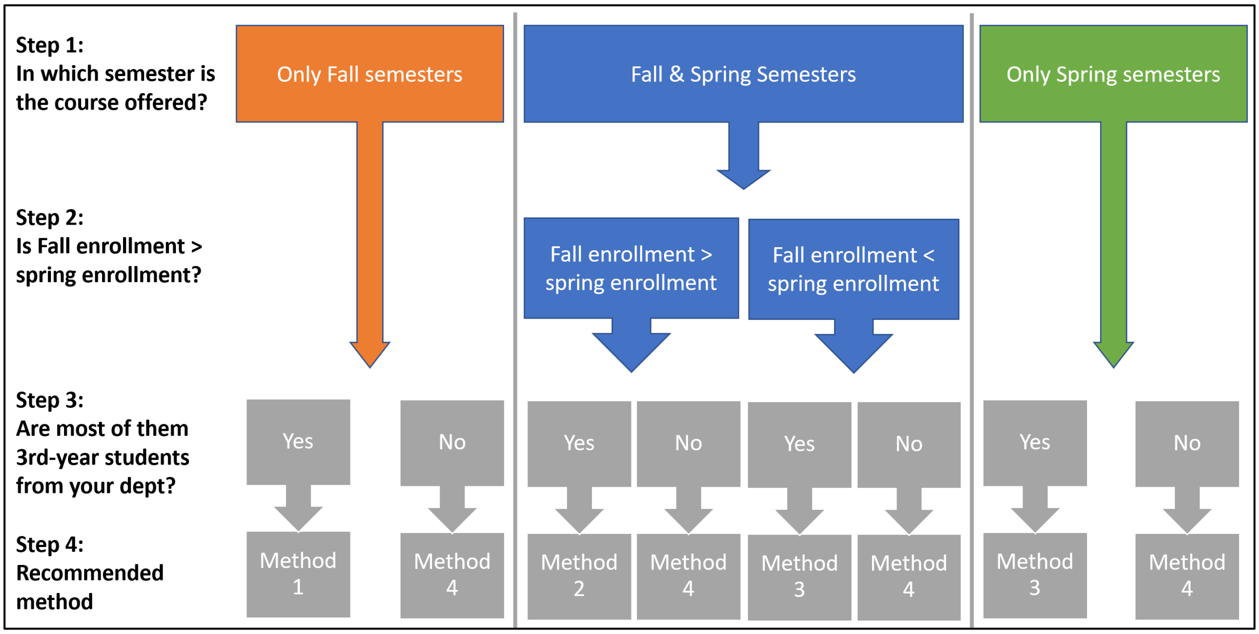


Figure 9: Flow Chart for Recommended Method Based on the Semester

The analysis for third year enrollments allows the academic programs to make several key decisions. Firstly, based on the third-year enrollments, department schedulers can use this data to determine room requirements, section sizes, and teaching assistant needs, as they plan and schedule rooms a year in advance. Secondly, the university requires that all engineering programs annually verify their entrance-to-major requirements (classes and GPA). This data allows programs to adjust their entrance-to-major requirements if needed for a cohort, ensuring they have a robust tool from the Data Analytics Team to support these decisions. For instance, the Aerospace program used this data to increase the GPA requirement by 0.1. Although this adjustment may seem minor, the prediction indicated that it would stabilize the trend line of junior course enrollments rather than continue on the upward trajectory.

Conclusion

BI Dashboards are an invaluable tool for summarizing and visualizing data, providing administrators with critical insights required for informed decision-making. This paper presented three case studies pertinent to the College of Engineering at Penn State University, highlighting the methodologies applied, the relevance of each approach, and the results achieved by the Data Analytics Team using Power BI Dashboards. The dashboards address most of the frequently asked data questions, allowing the Data Analytics Team to conduct more complex analysis, as illustrated by Case Study 1. The application of these Dashboards has proven essential in supporting strategic decisions, enabling the college to better align resources and hiring practices with departmental needs and the institution's broader goals. As institutions continue to prioritize data-driven decision-making, BI Dashboards will remain a key asset in optimizing operations and fostering long-term academic success.

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