

A Project-Based Approach to Integrated Business and Engineering Curriculum

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Introduction

This work in progress paper describes a new program that integrates business and engineering curriculum. Investments in science, mathematics, and engineering education have increased as a matter of national economic competitiveness [1]. Engineering and business are increasingly connected in today's technological and global workplace and there is a need for graduates whose competencies span these fields [2]. Educators have been developing approaches that link business and engineering curriculum within traditional classes [3,4] as well as programs that provide minors and degrees for students crossing traditional disciplinary boundaries of business and engineering [6-8]. Blended engineering and business baccalaureate programs have been developed by at least a dozen of universities in the US including Drexel, Lehigh, Ohio State, Penn State, California Berkeley, University of Pennsylvania, University of Tennessee Knoxville, Texas at Austin, Valparaiso, and Washington University in St. Louis.

This work in progress paper describes an approach at a large, research university that immerses business students into engineering project teams and introduces them to real-life complex engineering problems through two vertically integrated design programs. The first year of the curriculum includes all the first-year science and engineering core courses required for other engineering majors along with introductory accounting and microeconomics. The engineering coursework continues in sophomore and junior years through electives and design experiences. This paper describes how engineering is collaborating to add to the opportunities for business students and how it can open multidisciplinary opportunities for engineering students.

IBE Program Description

The Integrated Business & Engineering (IBE) program is a partnership through the Daniels School of Business and College of Engineering at Purdue University. IBE students are a part of a small cohort taking core courses together with the option to live within the same learning community as well. Students will graduate with an accredited AACSB business degree and with a substantial coursework in engineering. This integrated merger of disciplines prepares students to work at the intersection of business and technology with an engineering skill set and the ability to see the business implications across the organization. IBE has substantial and significant (5 semesters) hands-on project-based learning opportunities through proven programs within engineering as well as corporate partnerships within the course curriculum and co-curriculum, providing students an apprenticeship-like experience.

First Year Program

The first cohort of 94 IBE students began their studies in the fall semester of 2021 taking the same engineering core as First-Year Engineering students, as shown in Table 1, so they are positioned with the prerequisites for later engineering courses. Students are clustered with other

IBE students to create first-year cohorts to support their transition into the university. They are clustered within the first engineering course, Transforming Ideas to Innovation.

Table 1: First Year IBE Curriculum

Fall Semester (15 credits)	Spring Semester (15 Credits)
(4.0) Analytical Geometry & Calc I	(4.0) Analytical Geometry & Calc II
(4.0) General Chemistry	(4.0) Modern Mechanics
(1.0) EPICS or VIP	(1.0) EPICS or VIP
(2.0) Transforming Ideas to Innovation	
(3.0) Introductory Accounting*	(3.0) Microeconomics*
(1) IBE #1 Seminar*	(3.0) Oral Communication
*Not taken by engineering students	

They are also placed into one of two engineering programs, (VIP) or (EPICS), where teams of first-year students join more senior students on design and research teams. In VIP, teams of undergraduate students engage in authentic and extended research and design projects related to active research areas of Purdue faculty members and national, international, and industry-sponsored design challenges. The . Students can participate in interdisciplinary and vertically-integrated teams (first-year through seniors) with faculty and graduate student mentors for multiple semesters to address these real-world research and design challenges.

In EPICS, teams of undergraduates from more than 80 majors are engaged with community partners to address local and global needs. With guidance from faculty and industry mentors they identify needs and co-develop solutions to be deployed within the partner communities. Projects span multiple semesters and the partnerships span years and even decades. The students gain real design experience in an authentic setting, solving real-world problems while developing their technical and professional skillsets [9,10]. Students participate in EPICS at any point in their undergraduate curriculum using the courses to meet various program or elective requirements.

The IBE program also puts students through real-world learning simulations, preparing them for internships and future employment. Students engage industry stakeholders from the start and through curricula and co-curricular opportunities.

IBE Undergraduate Curriculum

The IBE curriculum (see Appendix) includes core business, engineering, and sciences classes as well as interdisciplinary seminars and electives in management, engineering, and mathematics providing a strong interdisciplinary foundation. Part of the core is engagement with active research or community-based design projects where they are mixed with engineering and other majors. The multi-year participation in the programs allows IBE students to serve in leadership positions on authentic projects and develop an understanding of working with engineers. Seminars expose students to contemporary topics related to the design and management of socially responsible modern organizations and enterprises. They leverage thought leaders on and off campus in rotating topic areas that include artificial intelligence, cybersecurity, climate resilience, and sustainable economic growth. The curriculum culminates in an industry-driven

capstone design course, strategic product/service development, and tactical product/service realization.

Other Opportunities

IBE students are encouraged to supplement their academic experiences with opportunities that are not exclusive to IBE but are aligned with and complement their programs. One example is the Certificate in Entrepreneurship and Innovation Program. Like a minor, the program is available to undergraduate students in all majors who want to transform their ideas into new ventures, generate value in established organizations, or have a positive impact on society. The coursework in their curriculum in VIP or EPICS can count toward the certificate.

In addition to the certificate, a series of challenges and competitions offer opportunities for students to explore entrepreneurial ideas. The first is the Moonshot Challenge in which teams identify a significant problem or need and conceptualize a solution and is held one month into the academic year. Many of the VIP and EPICS projects have the potential to be the basis for a commercial or social enterprise with significant and broad impact. The second is the Business Model Competition in which teams test the assumptions underlying the problem or need and develop a way to implement a solution. This follows one month after the moonshot challenge. There is a track for social entrepreneurship offering an opportunity for students to build on the work of EPICS teams and broaden the impact of those projects beyond their immediate community partners. The final experience is the New Venture Challenge in which teams present their business or social venture plan to individuals and organizations who may be willing to fund their for-profit or not-for-profit venture during the Entrepreneurial Expo at the end of the year.

Evaluation

The first cohort of 94 students is in their second year with a 90.1% retention rate. The overall academic performance has been strong examining their overall grades shown in Figure 1 as well as the grades earned in their engineering courses shown in Figure 2

Grade Distribution Comparison		A	B	C	DFW
Fall 2022	No Breakout	52.4%	28.1%	12.6%	6.8%
Summer 2022	No Breakout	66.7%	24.6%	4.3%	2.9%
Spring 2022	No Breakout	55.1%	26.5%	11.1%	7.3%
Fall 2021	No Breakout	38.9%	32.5%	19.1%	9.2%

Figure 1 Overall Grades for IBE Students (N=94)

Grade Distribution Comparison		A	B	C	DFW
Fall 2022	No Breakout	71.9%	18.2%	4.5%	5.0%
Summer 2022	No Breakout	100.0%			
Spring 2022	No Breakout	77.6%	19.7%		2.6%
Fall 2021	No Breakout	56.8%	21.9%	12.0%	8.7%

Figure 2 Grades for IBE Students in Engineering Courses (N=94)

Feedback from the first cohort revealed a significant stress level experienced by students in their engineering courses, especially in their first semester. Many felt they were not as prepared as their engineering peers. An online summer transition experience was developed in response to introduce students to computational tools for those who had not had any experience in programming and has been favorably received. The first cohort was a pioneering class and the presence of second year students who could reassure the first-year students has also helped.

Comments from students have been positive. One first-year student wrote:

IBE has completely transformed my perception of higher education. As I reached the end of high school, I felt uncertain about my future and the path I wanted to take. As a generalist, I work best in a team-based environment where collaboration is expected and encouraged. And yet, I've always maintained an interest in technical and engineering-based courses. It was nearly impossible to find a program that allowed me to pursue engineering-oriented passions while ensuring an emphasis on business and leadership.

Then, I discovered Purdue Universities Integrated Business and Engineering program. I was eager to learn about both engineering and management and understand the intersection between these industries. This major provides a unique blend of technical and business education and allows me to fully pursue my educational interests.

The hands-on learning experiences go far beyond the classrooms and have given me the opportunity to lead teams of aspiring engineering, navigate complex problems, and maintain real-world client relationships. I am proud to be a part of such a forward-thinking program and am deeply grateful for the opportunities that IBE has provided me. I never expected to have such a wealth of experience, and I am confident that this program has set me on the path toward a successful and fulfilling career.

A 2nd year student in a leadership position in the EPICS Program wrote:

From studying Integrated Business and Engineering I have gained skills in leadership, collaboration, and communication as well as learning technical and problem-solving skills and how to utilize the design process. The combination of studying both Business and Engineering disciplines has introduced me to a wide variety of careers in which both leadership and problem-solving skills will be necessary. I have been exposed to the most important aspects of both the business and engineering disciplines, which is extremely beneficial in a world where technology is becoming increasingly dominate.

Multidisciplinary teaming can be challenging; however, the response has been positive amongst the engineering students with the VIP and EPICS Programs. One of the engineering leaders in an EPICS team appreciated students who had expertise and interest in business aspects.

The introduction of IBE students to EPICS has brought a completely new perspective to our team's fundraising efforts. Our IBE team members have a strong interest in marketing and communicating our work to potential donors. They are also eager to learn about how to raise money in the highly saturated non-profit sector. It has been great to have more students in EPICS who are passionate about developing creative business strategies while also understanding the technical engineering behind our work.

Summary

Planning for years three and four is ongoing. The second cohort enrolled 96 students and the current plans are to cap enrollment at 120 for the third year of the program. Opportunities to leverage the new program for additional opportunities within and outside the curriculum are being explored that can open new opportunities for engineering students as well. This program is inspiring other business majors to add intensive experiential learning opportunities to the curriculum. The integration of business students with engineering in the VIP and EPICS programs has added new opportunities. The start was not without challenges with differing expectations from business and engineering among students and faculty. The intent is to create truly integrated opportunities that more closely align with modern professional environments. The complementary skills that the business students bring and new opportunities will be topics to be discussed and shared in future work. We are all learning together and are excited about the future this new program brings.

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Appendix
 IBE Curriculum Requirements

Integrated Business & Engineering Courses	
Business Core Courses (37 Credits)	Engineering Courses (6 credits)
Introductory Accounting (MGMT 20000)	General Chemistry (CHM 11500)
Accounting I (MGMT 20100)	Analytical Geometry & Calc I (MA 16500)
Microeconomics (ECON 25100)	Analytical Geometry & Calc II (MA 16600)
Python for Business (MGMT 38800)	Transforming Ideas to Innovation (ENGR 13300)
Intellectual Property (MGMT 49200)	Modern Mechanics (PHYS 17200)
Business Statistics (MGMT 30500)	First-Year Participation in EPICS or VIP 1
Financial Management (MGMT 31000)	First-Year Participation in EPICS or VIP 2
Marketing Management (MGMT 32400)	Engineering Expansion Course (<i>any ENGR, ABE or CHE available for non-engineering students</i>)
Strategic Management (MGMT 35200)	
Operations Management (MGMT 36100)	
Management Information Systems (MGMT 38200)	Engineering IBE Core Courses (6 credits) choose 6 credits hours from the courses below
Organizational Behavior (OBHR 33000)	Computations of ENGR Systems (ABE 20500)
Storytelling with Data (MGMT 49300)	Thermodynamics (ME 20000)
	Basic Mechanics (CE 29700) or Mechanics I (ME 27000)
Business Methods Electives (6 credits) Pick two of the below courses	Life Cycle ENGR & MGMT of Const Facilities (CEM 20100)
Management Science (MGMT 306000)	Environmental, Ecological & Engr Systems (EEE 25000)
Project Management (MGMT 46600)	Electrical Engr Fundamentals (ECE 20001)
Spreadsheet Modeling (MGMT 47200)	Environmental, Ecological & Systems Modeling (EEE 30000)
Predictive Analytics (MGMT 47400)	Probability & Statistics on Engr. (IE 23000)
	Engineering Economics (IE 34300) (SP)
Business Depth Course (3 credits) Pick one of the below courses	Structure and Properties of Materials (MSE 23000)
Managerial Economics (ECON 30100)	Intro. to Energy Engineering (NUCL 11000)
Int Accounting/Non-Acct Majors (MGMT 35300)	Nuclear Engr Undergrad Lab (NUCL 20500) AND Intro to Engr Practice: Nuclear Proliferation
Investments (MGMT 41100)	Intro To Nuclear Engr (NUCL 20000) AND Nuclear Structure & Radiation Interactions
Digital Marketing Strategy (MGMT 42710)	
Leadership & Org Change (MGMT 44362)	

Technology Strategy (MGMTM 44810)	Engineering Electives (3 credits) <i>Pick one</i>
Supply Chain Analytics (MGMT 46300)	It's a Complex World: Address GC (SYS 30000)
Data Mining (MGMT 47300)	Systems Theories & Approaches (SYS 35000)
Data Driven Decisions in Dig Mrkt (MRKT 48800)	Imagine, Model, Make (IE 47200)
Innovation Lab Courses (11-12 credits)	
(4) IBE Seminar/Special Topics (<i>MGMT 11000, MGMT 29110, 29120,29130,29140</i>)	Area Specialty Courses (12 credits)
(2) Team-based design in EPICS or VIP (EPCS 20100,20200,30100,30200, or ENGR 27920,37920) 2cr	Financial, Supply Chain Operations Management, Data Analytics, Student Designed Area (with advisor approval)
Capstone (MGMT 49400)	
	Electives (2-3 credits)
Other Course Requirements (16-17 Credits)	Choose 2-3 cr hours
Written Communication	
Oral Communication	
UCC: Human Cultures: Humanities Elective	
Multivariate Calculus (MA 26100)	
Probability & Statistics for Bus (STAT 30301)	