

Lessons Learned from 35 Years of Impact in the Leonhard Center for the Enhancement of Engineering Education

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Lessons Learned: 35 Years of Impact of the Leonhard Center for the Introduction

This Lessons Learned paper presents the 35-year history of The Leonhard Center for the Enhancement of Engineering Education [1]. The Leonhard Center is a teaching and learning center dedicated to the enhancement of engineering education within the College of Engineering at Penn State University. Established in 1990 by an alumnus of the university, William and Wyllis Leonhard, the Leonhard Center has the mission of catalyzing and supporting the enhancement of teaching, learning, and assessment at Penn State University to deliver world-class engineering education [1]. The Leonhard Center was the first of its kind to be housed within a College of Engineering, and was started well before doctoral degree granting programs were established. It is one of the pioneering centers for the enhancement of engineering education in the United States [2].

As we enter the 35th year of the Leonhard Center's existence, we reflect on its accomplishments. The purpose of this paper is to describe the Leonhard Center and its impact; utilizing an artifact analysis of advisory board meeting minutes and annual reports submitted by Leonhard Center-funded project grantees; as well as a discussion of the lessons learned after decades of contributions to College of Engineering program faculty, curricula, and teaching and learning.

Overview of the Leonhard Center

At its launch, the Leonhard Center included only a director and an administrative support specialist. Within the College of Engineering, there was a separate unit focused on instructional support working in parallel with the Leonhard Center. Eventually, this unit, along with other groups in the College, merged with the Leonhard Center to form one unit with the overall mission of enhancing engineering education. Today, the Leonhard Center includes the director, who is also an assistant dean within the College; an administrative support specialist; the assessment and instructional support group; the Engineering Ambassadors (a professional development group for undergrads who conduct K-12 outreach); and engineering communications.

Some of the major accomplishments of the Leonhard Center include graduate student training (for over 1,500 over the last 10 years), faculty development (hosting over 70 workshops over the last 10 years with over 1,300 participants), creating online engineering writing and presenting resources that have been viewed over 300,000 times, provided initial funding for the College's Learning Factory (the College's maker space), provided initial funding for the entrepreneurship minor (which eventually became a university-wide minor), provided initial funding for the engineering leadership minor, and was a leader in initiating the College's micro-credential initiatives – and many more. Themes and other major accomplishments are highlighted in the timeline in Appendix A and discussed in the next section "Themes through the years".

Over the 35-years of the Leonhard Center, funding faculty-led teaching innovation projects has been a foundational initiative of the Leonhard Center and a prime source for where funds are distributed. Historically, the Leonhard Center was able to provide Leonhard Center faculty work with a small number of project teams to complete thorough evaluations of the projects. However, with the growth of project funding (from 2015-2023, 83 projects were funded), the larger number of projects being funded limited the direct involvement of Leonhard Center faculty on many projects. In Spring 2024, the Leonhard Center decided to assess every funded project within the previous six years by requiring that Principal Investigators (PIs) submit a report. Such a report helps the Leonhard Center to assess project impacts and processes. Table 1 in the below "Project evaluation" section provides descriptive results from the evaluation. Some recent project highlights include: using emerging technologies like Virtual Reality (VR)/Augmented Reality (AR) and Artificial Intelligence (AI) to promote classroom engagement; creating micro-credentials for robotics,

engineering literacy, engineering writing, inclusive teaming, extra-curricular clubs recognition, and ethics; multiple department-level Diversity, Equity, and Inclusion (DEI) programs; creating an Academic Job Market Seminar for graduate students; and many more.

Themes through the years

Appendix A shows a timeline of the history of the Leonhard Center and themes that emerged as focal points for the center as communicated through their work with an industry advisory board, from the first meeting of the board in 1991 through the year 2024. To reiterate, the themes were found through reviewing archival records of past advisory board meetings. The timeline highlights the major themes that the Leonhard Center pursued by year. Important dates related to the Leonhard Center are also highlighted by year. Overarching themes included student development (SD); faculty development (FD); DEI initiatives, including gender equity and racial/ethnic equity; informing the curriculum (CUR); entrepreneurship (ENT); globalization (GLO); online programs (OP); ethics (ETH); graduate education (GE); entrance to undergraduate engineering majors/first-year experience (FYE); responding to the COVID-19 Pandemic (COVID); artificial intelligence (AI); and impact of the Leonhard Center (IMP). The overarching themes are color-coded in the second column to help highlight patterns throughout the years, as well as highlighted in the Appendix A Legend.

DEI efforts as a theme can be seen from the start of the Leonhard Center through 2021. The engineering curriculum was a major theme at the start of the Leonhard Center through 2002. Entrepreneurship was a main theme in 1998 and 2001. Ethics was a major theme from 2010-2015, and again in 2022. Graduate education became a focus from 2015-2018, as the mission of the Leonhard Center expanded to include graduate education (as the endowment income and capacity grew). Globalization was highlighted from 2004-2014. Concern over FYE can be found throughout the history of the Leonhard Center. Responding to the COVID-19 Pandemic was as a theme from 2020 through 2022. Measuring and sharing the Leonhard Center's impact is a current theme from 2023 to present, and AI is a newly emergent (2024) and future theme the Leonhard Center is exploring. Some of the Important Events highlighted in the last column cover the creation/introduction of the Engineering Leadership Development Minor, the Engineering Entrepreneurship Minor, and The Learning Factory. Also highlighted under Important Events is the creation of the definition/attributes of a World Class Engineer, and Penn State University's partnership with Kern Entrepreneurial Engineering Network (KEEN), led by the Leonhard Center.

Center effort within the engineering education field

The history of the Leonhard Center over the past three decades highlights its vision and leadership in engineering curriculum reform. This includes its early initiative to invest in an Engineering Leadership minor, entrepreneurship, and the Learning Factory (university maker space). These efforts align with the National Academy of Engineers' 2020 call to equip engineers with leadership, creativity, and interdisciplinary skills [3]. Additionally, DEI has been a persistent theme since the inception of the Leonhard Center. This is in line with the engineering education field's endeavor to broaden participation in engineering and create a more inclusive and excellent learning environment. Also, the Leonhard Center's focus on faculty and student development aligns with national efforts to improve engineering education through pedagogical training and professional development. Both the American Society for Engineering Education (ASEE) and the National Science Foundation (NSF) have emphasized the need for faculty to adopt evidence-based pedagogical practices [4].

Furthermore, the Leonhard Center's emphasis on globalization (2004-2014) aligns with the call for globalization of engineering education to ensure that students develop competencies for global collaboration and problem-solving [5]. In addition, the Leonhard Center's recent focus on emerging technologies such as AI (2024-present) aligns with a recent call by UNESCO and other engineering education researchers for AI literacy and the adoption of AI to enhance students' learning and instructors' teaching within ethical

boundaries [6], [7]. Finally, the Leonhard Center's emphasis on measuring its own impact (2023-present) mirrors broader conversations in higher education about accountability, assessment, and data-driven decision-making [8].

Project evaluation

Of the **60 funded projects** between 2019-2023, 47 submitted their evaluation reports. **Approximately 128 faculty** were listed as PI or Co-PIs on the projects, with some being active on multiple projects over the years. PIs reported an impact on **more than 12,037 students** with their projects. PIs were given a list of Likert-type items to rate their agreement about their experience working on their Leonhard Center projects. It is important to note that not all projects were focused on the classroom; some were focused on the overall curriculum or co-curricular activities. Overall, faculty PIs found working on projects funded by the Leonhard Center to be positive and impactful experiences. Table 1 shows descriptive results from the evaluation.

	Neither						
	Strongly	Somewhat	agree nor	Somewhat	Strongly		
Likert-style items	disagree	disagree	disagree	agree	agree	Avg.	
I find value in working with the	0	0	1	7	35	4 79	
Leonhard Center through proposals.	Ŭ	Ŭ	1	,	55		
I plan to submit another Leonhard Center	0	0	10	13	20	4.23	
proposal.							
I would recommend submitting a		0	0		10	1.00	
Leonhard Center proposal to my	0	0	0	1	42	4.98	
colleagues.							
The Leonhard Center project led to new	0	0	4	15	24	4.47	
Ideas related to teaching innovation.							
discominate the outcomes of the project	0	2	5	14	21	4 20	
to a broader audience	0	2	5	14	21	4.29	
Leading this Leonhard Center project							
helped me to be a more inclusive	0	0	1	16	26	4.58	
teacher.	0	Ŭ	-	10			
helped me to build or strengthen	0	0	7	12	24	4.40	
relationships with my colleagues.	-						
helped me to build or strengthen	0	0	7	16	20	4.30	
relationships with my students.	-						
helped me to feel more confident in	0	0	9	13	21	4.28	
my teaching.							
helped me to improve my course.	2	2	5	9	25	4.23	
improved student learning in my	0	0	10	8	25	4 35	
classroom.	0	0	10	0	25	4.55	
increased my knowledge of engineering education as a field.	0	0	5	11	27	4.51	

Table 1. Summary of Faculty responses to Likert-style items about their experiences.

*Note: 43 out of 47 respondents completed the Likert-style items

Lessons Learned

Many faculty, staff, graduate students, and post-docs have dedicated time and energy into making the Leonhard Center as successful as it has been over the last 35 years. From our experiences working with the Leonhard Center and our time reflecting while preparing this paper, we provide the following lessons learned:

Reflects the socio-political themes of the times and needs of students and faculty

One goal of the Leonhard Center is to be at the forefront of educational innovation and to enable the students within the College of Engineering to be as successful as possible in their future careers. Workshops, funding, and other activities are driven by what the needs of the faculty and students are as well as broader societal trends. As reflected by Appendix A, the focus and shifts of the Leonhard Center have often reflected the socio-political themes of the day, such as globalization, retention and diversity; and the importance of professional skills, like leadership and entrepreneurship. The Leonhard Center initially focused on very practical, student-oriented questions such as, "How do students learn hard concepts in fundamental engineering courses?" Over time, the trends have shifted to reflect sociopolitical trends and the needs of current students and faculty. Most recently, the emphasis has been on inclusive teaching, mental wellness, and AI.

Lesson learned: Centers must think about the CURRENT needs of their faculty and students while thinking forward to constantly evolve.

Informed by research in both education and engineering education

Through professional development, the Leonhard Center faculty have to be active and engaged within the scholarly field of engineering education. Initially, this was present through frequent collaborative efforts with the College of Education. Today, we still work regularly with the College of Education, but as the field of engineering education evolved, the faculty within the Leonhard Center were able to grow their expertise. More recent hires into the Leonhard Center have PhDs in Engineering Education. To stay current, the faculty of the Leonhard Center have been active in service to the field of engineering education and have been active scholars through their research. It should be noted that in 2003, the *World Class Engineer* was developed by the Leonhard Center and its advisory board to support developing well-rounded engineering professionals. The tenants of the *World Class Engineer* are similar to those reflected by the Engineer of 2020 and the ABET a-k criteria developed and publicized years later. This is now referred to as ABET criteria for student outcomes 1-7 [7].

Lesson learned: Utilize being grounded in scholarly research to externally disseminate your efforts.

Measuring impact

Over the last 35 years, the Leonhard Center has led impact assessments of numerous internally and externally funded projects in the College of Engineering at Pennsylvania State University. Recently, the Leonhard Center decided to begin measuring our impact. We hired an external evaluator to complete an evaluation of our center, and as noted above, we have started collecting annual reports from our project PIs to capture the Leonhard Center's funded project impact. Moving forward, we aim to capture faculty experiences and stories from working with the Leonhard Center as part of our celebration of 35 years.

Lesson learned: Assess yourself. Measuring the impact of a teaching and learning center is hard, but worth the effort.

Money does not solve everything

The College has been very fortunate that with the support of an endowment, financial security has not been a concern for the Leonhard Center. However, even with funding, institutional change is slow. We continue to adapt and try new things – and money helps, but it does not solve all the problems.

Lesson learned: Never give up! Never Surrender! Keep working to improve engineering education.

References

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Appendix A: Timeline for the Leonhard Center by Year, Including focus themes for the Center

Legend	[-			
DEI = Diversity, CUR = SD = Student FYE = Entrance				e to Undergraduate				ENT =		IMP – Impact			
Equity,	quity, Inclusion Curriculum Development Engineering M		ajors/First Year Experie		nce Entrepreneurship		reneurship	IIVIF – IIIpaci					
GLO =		OP = Online	AI = Arti	ificial	GE = Gra	duate	FD :	= Facult	ty I	ETH =	COVID = C	COVID-19	
Globali	zation	Programs	Intelligen	nce	Education	ı	Dev	elopmei	nt 🛛	Ethics	Pandemic		
Year	Year Themes by Year		Overall Themes		emes	Important Events							
1991	1991 Inclusion Curriculum Learning			CUR		First Advisory Board Meeting							
	Creativity. In	nnovation. Stud	lent Involvem	ent. D	iverse			COR		Center Officially Opens at Pennsylvania			
1992 Retention		DEI			State University								
1993	Diverse Rec	ruitment Activ	e Learning L	eader	shin Design	-	SD						
1775	1995 Diverse Recruitment, Active Learning, Leadership, Design			50		Engineering Leadership Development Minor							
1995	1995 Undergraduate Education/Curriculum, Student Excellence		CUR			hegins							
1006	Landarshin						SD			Learning Factory Opens			
1990	Leadership	ata/Einst Vaan E	Iducation				SD EVE		Learning Factory Opens				
1997	Undergraduate/First-Year Education				CUD								
1998	Retention, C	urriculum, Ent	repreneursnip)		CUK	ENT						
1999	Curriculum, Faculty Development					FD							
2000	Undergradua	ate Core Curric	ulum				CUR						
2001	Entrepreneu	rship, Teaching	; & Learning			ENT	1	FD					
2002	Curriculum,	Faculty Develo	opment			CUR	-	TD		Engineering Entrepreneurship Minor begins			
2003	Job Readine	ss of Graduates	3				SD		Wor	rld Class	Engineer begi	ins	
2004	Global Mark	cetplace, Offsho	oring				CLO						
2005	Engineering Ed. in a "Flat World"			GLU									
2006	Globalize C	urriculum, Inte	rnational Prog	grams,	Skills for	CT O	CD						
2006	¹⁶ Global Workplace, Online/E-Learning		GLO	SD	SD OP								
2007	Internationalization, Globalization, E-Learning				GLO	(OP						
	Global Student Engagement, First-Year Engagement,												
2008	¹⁸ Leadership				FY								
	2009 International Experiences for Students, First-Year Engagement		GLO	SD E		Restructuring of College teaching supports							
2009						into	the Leon	hard Center	such and supports				
			G E		DF	_							
2010	Online Cour	ses, Global Eth	nics, Innovatio	on/Cre	ativity,		OP	EY	Bus	iness Bas	ics & Techno	logy,	
Gender Equity in Recruitment, First-Year E		r Expe	erience	O H	· · ·	ΙĒ	Glo	balization	i, and Ethics of	courses online			
	Recruit Diverse Students and Faculty Online Programs		Programs										
2011	Ethics	ense stadents a	id i acuity, Online i logranis,		ETH	OP DEI							
2012	Ethics Educ	ation Academi	Integrity			FTH							
2012	Ethics Education, Academic Integrity												
2013	Ethics, Non-Travel Based Global Experiences			GLO									
2014	Ethics, Ellio	tivos Mostor's	L aval Engina	aring	(ENC)	ETH							
2015	Education	lives, master s	Level Englied	ering	(ENG)		GE						
2016	Education ENG Master	r'a Improvemen	nt/A second	•			CE						
2010	ENG Master			L Enders	4.		UL						
2017	ENG Master	ENG Master's: Enrollment/Assessment, Entrance to		EVE	GE								
2010	Undergradua	ate ENG Major	S IIII		<u> </u>	FYE	DEI						
2018	Gender Equ	ity, Entrance to	Undergraduat	te EN	G Majors		DEI						
2019	Engineering	Equity Initiativ	ve, Inclusion			DEI							
2020	Engineering Equity Initiative, COVID-19				COV	Т	DEI						
				ID		2.21							
2021	Engineering Equity, Student DEI Skill Development,				COV		DEI						
2021	COVID-19 Pandemic			SD									
2022	Student Prof	tessional Comn	nunication Ski	ill Dev	velopment,	ID		ET					
2022	Ethics, COV	ID-19 Pandem	ic					H					
2023	Measuring I	LC Impact					IMP						
2024	Measuring I	C Impact, Entr	repreneurial M	/indse	et, Student	IMP		AT	Dart	nerchin u	vith KEEN		
Engagement, Artificial Intelligence			IIVII		AI		i armeisnip with KEEN						

* Note: Data from 1994 was not available