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Faculty Development Aimed at Sustaining and Enhancing Entrepreneurial-minded Learning

Dr. Nadiye O. Erdil, University of New Haven

Nadiye O. Erdil, an associate professor of industrial and systems engineering and engineering and operations management at the University of New Haven. She has many years of experience in higher education and has held several academic positions including administrative appointments. She has experience in teaching at the undergraduate and the graduate level. In addition to her academic work, Dr. Erdil worked as an engineer in sheet metal manufacturing and pipe fabrication industry for several years. She holds B.S. in Computer Engineering and M.S. in Industrial Engineering. She received her Ph.D. in Industrial and Systems Engineering from Binghamton University (SUNY). Her background and research interests are in quality and productivity improvement using statistical tools, lean methods and use of information technology in operations management. Her work is primarily in manufacturing and healthcare delivery operations.

Dr. Ronald S. Harichandran, University of New Haven

Ron Harichandran is Dean of the Tagliatela College of Engineering and is the PI of the grant entitled Developing Entrepreneurial Thinking in Engineering Students by Utilizing Integrated Online Modules and Experiential Learning Opportunities. Through this grant entrepreneurial learning has been integrated into courses spanning all four years in seven ABET accredited engineering and computer science BS programs. Faculty development on entrepreneurial minded learning is a part of this effort.

Dr. Maria-Isabel Carnasciali, University of New Haven

Maria-Isabel Carnasciali is an Assistant Provost for Program Assessment and Effectiveness at the University of New Haven, CT. She is also an Associate Professor of Mechanical Engineering in the Department of Mechanical and Industrial Engineering. She obtained her Ph.D. in Mechanical Engineering from Georgia Tech and her Bachelors of Engineering from MIT. She has over 12 years of experience in faculty development efforts; focusing the last 6 years on the integration of entrepreneurial mindset into the curriculum. Her engineering education research focuses on the nontraditional engineering student – understanding their motivations, identity development, and impact of prior engineering-related experiences. Her work dwells into learning in informal settings such as summer camps, military experiences, and extra-curricular activities. Other research interests involve validation of CFD models for aerospace and industrial applications, as well as optimizing efficiency of thermal-fluid systems.

Dr. Jean Nocito-Gobel, University of New Haven

Jean Nocito-Gobel, Professor of Civil & Environmental Engineering at the University of New Haven, received her Ph.D. from the University of Massachusetts, Amherst. She has been actively involved in a number of educational initiatives in the Tagliatela College of Engineering including KEEN and PITCH, PI of the ASPIRE grant, and is the coordinator for the first-year Intro to Engineering course. Her professional interests include modeling the transport and fate of contaminants in groundwater and surface water systems, as well as engineering education reform.

Dr. Goli Nossoni, University of New Haven

Dr. Goli Nossoni is currently an Associate Professor in the Department of Civil and Environmental Engineering at University of New Haven. She received her M.S. and Ph.D. from Michigan State University in civil engineering. In addition to her interest in engineering education, Dr. Nossoni specializes in the research areas of concrete materials and corrosion of steel inside concrete.

Dr. Emese Hadnagy, University of New Haven

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Emese Hadnagy is an associate professor at the Department of Civil and Environmental Engineering at the University of New Haven; she received her Ph.D. at the University of New Hampshire. She is also the director of both the on-ground and fully online MS environmental engineering programs at the University of New Haven. She teaches courses in water resources and environmental engineering both at the undergraduate and graduate level, and one of her interests is to develop an entrepreneurial mindset in her students. Her research focuses on surface water quality assessments, contaminant fate and transport studies, and innovative treatment technology development.

Dr. Joseph A. Levert, University of New Haven

Dr. Joseph A. Levert, P.E. (M'05) received his BS in mechanical engineering from Tulane University, New Orleans, LA, USA in 1981, his MS in mechanical engineering from Arizona State University, Tempe, AZ, USA in 1990, and his Ph.D. in engineering from the Georgia Institute of Technology, Atlanta, GA, USA in 1997. He is an Associate Professor in the Mechanical and Industrial Engineering Department at the University of New Haven. Previously, he was an Associate Professor at the State University of New York, Maritime College. He has practiced engineering in the petroleum, aerospace, integrated circuit fabrication and fiber-optics industries. Dr. Levert is a member of STLE, and ASME, and was awarded the best paper award by the ASME Tribology Division in October 2000 (as co-author) for "Interfacial Fluid Mechanics and Pressure Prediction in Chemical Mechanical Polishing".

Dr. Junhui Zhao, University of New Haven

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Abstract

Many higher education institutions have begun promoting an entrepreneurial mindset (EM) in students and integrating entrepreneurship elements in engineering education. Various approaches, including curricular, extra-curricular and co-curricular initiatives, are being used to transform the education offered at these institutions. However, in order for this transformation to be sustained and broadened, efforts must target faculty as well as students. Helping faculty to embrace entrepreneurial minded learning (EML) and equipping them with relevant tools and resources will ensure true transformation and long-term success. At the University of New Haven, our efforts started with implementing an innovative curricular model designed to develop an entrepreneurial mindset in students and establishing initiatives to provide students other forms of engagement opportunities. The curricular model involved the development and integration of e-learning modules — targeting various entrepreneurial concepts and skills — into courses spanning all four years of all engineering and computer science programs. Innovation and pitch competitions, participation in the University Innovation Fellows program, and an entrepreneurial engineering living learning community were primary extra-curricular components. Faculty development opportunities were provided as part of these initiatives including training for effectively integrating the e-learning modules into courses, participation in workshops and conferences with a focus on entrepreneurial education, and involvement in organizing and facilitating student activities. While a significant number of our engineering and computer science faculty participated in these development opportunities, in general their enthusiasm related to entrepreneurial minded learning (EML) was not strong enough to sustain and further broaden EML within the college. Therefore, we implemented a faculty development program aimed at fostering EM champions from different engineering and computer science disciplines, as well as a mini-grant program to stimulate faculty to independently integrate EML into their courses. In this paper, we present these efforts, describe the program components, and report on findings. Sample products resulting from the faculty development efforts are also provided.

Introduction

The University of New Haven was invited to become a member of the Kern Entrepreneurial Engineering Network (KEEN) in 2011 through a pilot grant from the Kern Family Foundation. Early work included initial curricular and co-curricular efforts to develop an entrepreneurial mindset (EM) in engineering students. The university received a large institutional grant in 2014 to develop and launch comprehensive curricular and co-curricular efforts to develop an EM in all engineering and computer science undergraduate students. The curricular efforts consisted of developing 18 e-learning modules and integrating them into courses in all programs. The co-curricular efforts included developing an entrepreneurially oriented Living Learning Community (LLC) for first-year students, and conducting entrepreneurially focused competitions. A core team consisting of the dean and four faculty led these efforts, and other faculty were progressively engaged to participate in these efforts.

Internal efforts to develop the EM of faculty was not the primary focus from 2011 to 2019, except for training faculty on how to integrate the e-learning modules into courses. However, faculty were encouraged to pursue external opportunities to develop an EM by attending workshops and conferences sponsored by KEEN. As the development and integration of the e-learning modules matured, it became clear that a strong internal effort to develop an EM in faculty was needed to sustain the initiatives. A formal program consisting of developing EM champions across different programs was launched in 2019, and an internal mini-grant program to incentivize faculty to develop entrepreneurially minded activities in select courses across different programs was launched in 2020. This paper describes the outcomes of the various faculty development initiatives.

It is often the case that individuals engage and promote practices in which they themselves were trained [1]. Large-scale changes often require efforts to expose, train or retrain the individuals in new ideologies, content, and methodologies. This is true of academic settings and especially of faculty, many of whom may not have received formal training on teaching practices. Faculty development (FD) as a means of instigating change is, for instance, well documented in the medical professions [2,3]. Within engineering, perhaps the best-known example of FD effort is the National Effective Teaching Institute (NETI), which has for three decades trained and motivated engineering faculty to diffuse best practices in teaching [4]. Many of the partner universities in KEEN have focused their efforts on FD as a means to train faculty to develop the EM of their students. Presentations at KEEN meetings and conferences provide insights into that and KEEN annual reports also document many of these efforts. ASEE conference proceedings primarily focus on the curricular outputs from these efforts, and a few focus on the FD efforts themselves. The recently added ASEE Faculty Development Division will likely contribute to better documentation of such efforts. One of the earlier mentions of faculty development efforts to cultivate EM was at Lawrence Technological University [5], which briefly mentions workshops for faculty as a way to showcase effective EM pedagogical techniques. However, the evaluation of their programmatic efforts centered on assessment of student learning at the course level and not on the actual effectiveness of their FD efforts as a whole. It is worth noting that the efforts at Lawrence Technological University grew into what became the KEEN *Integrating Curricula with Entrepreneurial-mindset (ICE) Workshops.* A conference article by Baylor University notes that their approach is "different [as] it concentrates on [their] efforts to change faculty members" [6]. Their efforts included leveraging the *ICE* Workshops for faculty development, faculty lunchtime seminars, end-of-term faculty workshops, and in-house innovators program. It is worth noting that Baylor joined the KEEN network in 2008 and a major component of their institutional grant was on faculty development. At the time of writing their paper, they reported that their faculty had produced approximately 32 papers over the 7-year span of their effort. More recently, Dillon et al. described the intercollegiate coaching model employed by the KEEN Faculty Development workshops [7].

Motivation and Background

In seeking an institutional grant from the Kern Family Foundation in 2014, the Tagliatela College of Engineering at the University of New Haven embraced the value of its students having an EM. Most of our graduates pursue careers in industry and the core faculty team that led the institutional grant firmly believed that an EM would give students a competitive edge in the job market in the near term, and make them creative go-to leaders within their companies as

they progressed in their careers. Broadly embracing EML in all of our engineering and computer science programs would also enable branding of the college that could distinguish our programs from our competitors.

The framework we adopted for instilling EM in our students is rooted in the 3C's, core elements of an entrepreneurial mindset as defined by KEEN [8]. Based on the 3C's, entrepreneurially minded individuals are: 1) **C**urious about the rapidly changing world around them; 2) adept at making **C**onnections between ideas and information; and 3) able to **C**reate extraordinary value from opportunities that arise from these connections. Coupling technical skills with an entrepreneurial mindset in this framework empower engineers to recognize and act upon opportunities that create value for themselves and others. More details about the framework can be found at https://engineeringunleashed.com/framework. Initial funding allowed the core team to participate in network events, build relationships with other KEEN institutions, and support student curricular and extra-curricular activities. Initiatives in the first few years were more student-focused rather than on faculty development. However, faculty participation in KEEN sponsored events was encouraged by the Dean. Early opportunities for faculty in the college to learn about EM and the initiatives of KEEN partners to instill EM in their students included half-day workshops and presentations during college retreats. Monthly lunch meetings sponsored by the Dean's Office helped to promote interest in EM and move the initiative forward. However, these initial efforts resulted in a limited number of faculty actively involved in EM initiatives.

An increase in faculty engagement occurred in 2014 as opportunities to integrate EM content throughout the engineering and computer science curricula using the e-learning modules became a focus in the college with the large institutional grant received from the Kern Family Foundation. The development and integration of the modules is described in previous papers [9,10]. This effort required faculty from all majors to contribute to the development and deployment of contextual activities that reinforced module content in their courses. Courses taken by multiple majors such as two first year engineering courses and senior level capstone courses were first identified. Faculty were recruited to deploy specific e-learning modules in these courses. With the completion of each e-learning module, integration of modules involved more discipline specific courses providing opportunities for faculty from all majors to participate in this effort. Incentives and training provided to faculty for initial deployment of an e-learning module are discussed later.

While faculty deploying the modules received an overview of EM, development of an EM in faculty was primarily supported externally through participation in KEEN sponsored workshops, conferences and meetings. During the summer of 2014, the college hosted an ICE Workshop sponsored by KEEN. This faculty development workshop attended by faculty from KEEN institutions provided training on integrating PBL/EML modules in courses. Faculty from the university who participated deployed their modules in coursework during AY 2014-2015. Participation in ICE workshops continued to be encouraged, providing faculty with tools and resources for implementing EML in coursework. Funding was also provided each year for one or more new faculty to attend the KEEN Annual Conference where they participated in workshops on EML, learned effective strategies used by other institutions for promoting EML, and collaborated with other KEEN members.

Participation of faculty in extra-curricular activities promoting an EM in students likewise increased in 2014. Student entrepreneurially focused competitions like the 24-Hour Imagination Quest and Charger Startup Weekend provided faculty opportunities to be mentors and judges. The first-year Engineering Living Learning Community (LLC) began supporting activities promoting an EM. LLC Discussion Dinners provided a forum for faculty to share their own research or experiences related to an EM with students.

The University of New Haven places high value on teaching and faculty efforts toward EML are valued within this context when evaluating faculty for tenure and promotion (T&P). Faculty report their EML activities in their annual faculty activity reports as well as in their T&P portfolios. The support of the Dean for EML and his active role in recruiting faculty to participate in EML activities served as a catalyst for mobilizing faculty. The Dean worked with faculty in each program to identify target courses into which e-learning modules were integrated, and each member of the core team was assigned to specific modules to coordinate activities needed for successful deployment. The coordinators followed up with the Office of e-Learning and faculty to ensure that the appropriate modules were loaded into the Learning Management System for their courses; and worked with instructors of specific courses to provide assistance in developing contextual activities and to remind them to perform assessments and collect student feedback.

From 2014-2019, there was considerable growth in the number of faculty supporting student extra-curricular activities and integrating EML content through deployment of e-learning modules or incorporation of PBL/EML modules in their courses. However, sustaining that growth had its challenges as faculty responsibilities and interests changed, resulting in programs having only one or two full-time faculty actively involved in these efforts. It became apparent that a structured internal effort to develop an EM in faculty was needed to sustain and expand EML initiatives in the college.

Program Components

Faculty Development Related to Integrating E-Learning Modules into Courses
The model of integrating e-learning modules into existing courses required the involvement of a large number of faculty, many of whom did not have prior exposure to EM. A standardized training workshop was developed and conducted to ensure that the faculty were familiar with the knowledge and skills that characterized an EM, the e-learning modules, the strategies to deploy them effectively in their courses, and the other components of EML initiatives in the college. The training consisted of a half-day workshop held in the early phases of the program in January 2015 (6 full-time, 2 part-time faculty) and August 2015 (13 full-time, 9 part-time faculty), and addressed the items listed in Table 1. The deployment of the modules involved mostly the same group of faculty until fall 2018. Therefore, between spring 2016 and spring 2018 the training was shortened to a review conducted by coordinators of each e-learning module with faculty deploying the modules. Another half-day workshop was conducted in August 2018 (23 full-time, 2 part-time) as a refresher and as more faculty became involved in the effort. Trainings since then consisted of the short version for existing deployers and one-on-one meetings between coordinators and faculty new to the deployments. At the end of each deployment, feedback from students and faculty were collected. This feedback was used mainly to revise the modules to enhance content and to streamline the deployment process.

Table 1 E-Learning Modules Deployment – Faculty Training Elements

Item	**Content**
Program Introduction	Overview and objectives; Elements (e-learning modules, extra-curricular activities EM elective course, Entrepreneurial Engineering Living Learning Community)
Entrepreneurial Mindset	What is EM; EM attributes and skills
E-learning Modules	Topics; Integration strategy
Materials for Deployment	Contextual activity to reinforce learning of the module topic; Step-by-step outline for deployment & the time line; Assessment activities; Navigating the module in the LMS

The core team leading the development and integration of this curricular model provided the primary support for EML and module deployment related questions and needs. The trainings provided faculty exposure to EM in general and the deployment of the e-learning modules in their courses allowed integration of material aimed at developing an EM in students. However, the overall effort did not have strong elements to help faculty embrace EML and equip them with relevant tools and resources.

Faculty Development through KEEN Workshops and Conferences

Across the KEEN network, efforts to embed entrepreneurial concepts into engineering curricula have resulted in a proliferation of faculty development workshops offered by various universities. These workshops, many funded through Kern Family Foundation grants, were offered not just for the local faculty at the institution organizing/offering the workshops, but were open to faculty from other KEEN institutions. For many years, the most recognized workshops were the 3-to-5 day ICE Workshops organized by Lawrence Technological University. Stipends were paid to faculty for attending as well as subsequently delivering teaching modules with details of the modified curricula. In 2019, the Kern Family Foundation began to centralize the organization of the various workshops, broadening the types of workshops, and instituting a coaching program to support faculty to develop and embed EM modules into their own courses. Promoting participation at these network workshops became a part of our faculty development efforts. This supplemented our own efforts at introducing EM concepts to faculty and increasing the number of course offerings that included EML in addition to those utilizing our own e-learning modules.

We also leveraged the KEEN Annual Conferences as a way to introduce the ideology and practices central to EML to our faculty. The conferences provided keynote speakers, workshops, presentations, and networking opportunities and exposed our faculty to a broad array of EML efforts undertaken at other institutions. It also provided an engaging setting to include and involve non-engineering faculty, such as chemistry and business faculty.

Developing EM Champions Across Programs

The training activities to help faculty integrate the e-learning modules into targeted courses was a broad effort involving many participants. However, very few of the faculty developed depth and passion in EML to become champions of EML within their programs. As the work of developing the 18 e-learning modules neared completion, effort was focused on internal activities to develop

the EM of faculty. The first step to deepen deployment of EML within programs was to develop EM Champions. During the spring of 2019, five faculty from civil, electrical and mechanical engineering, computer science and engineering education were selected to be developed into EM Champions. We wanted to select one faculty from each program who had significant undergraduate teaching responsibilities. We identified faculty who had shown enthusiasm for EML by attending KEEN workshops and conferences. Some faculty who were initially identified declined our offer due to other commitments. A modest stipend was provided to incentivize the five EM Champions to participate in the faculty development efforts.

The activities to develop the EM Champions were the following:

1. Each EM Champion attended one of the KEEN Summer Workshops held in summer 2019. A requirement of attending these workshops was for the faculty to then integrate what they learned in their workshop into one of the classes they taught during the following academic year.
2. During fall 2019 and spring 2020, monthly meetings were held that included the EM Champions and members of the core team. These meetings consisted of discussions related to an EM and presentations on how the EM Champions were integrating what they learned in the KEEN Summer Workshops into their courses. The intent of these meetings was to deepen the EM of the champions and provide feedback regarding their efforts.

Expansion of Faculty Involved with EML

A mini-grant program was launched in fall 2020 to expand the number of faculty involved in integrating EML within courses that did not deploy one of the e-learning modules. All faculty who were not EM Champions were invited to submit proposals on how they would integrate EML within courses. The program requirements were designed in a way to foster exploration and adoption of EML approaches, strategies and practices. To apply, faculty were asked to select an undergraduate engineering, computer science or cybersecurity and networks course that they would teach in the 2020-2021 academic year, and revise it to infuse EML. The faculty were encouraged to review cards published in EngineeringUnleashed.com to find potential ideas and implementations of EML in specific disciplines. As part of the application, they were asked to describe their planned effort to promote EML in their course and identify the learning outcomes. The primary deliverables were to implement the proposed EML component and provide a detailed summary of their deployment including assessment efforts for dissemination through EML focused college and external meetings and events.

Participation from Faculty, Outcomes & Assessment

The faculty development opportunities described above reached a large number of faculty in the college. The participation rates in each activity and the broadening of faculty engagement in EML can be seen in Table 2. Faculty attended some of these events multiple times; the detailed timetables under the Time Period column show only the number of participants who have not gone through the same activity in earlier periods.

Table 2 Number of Faculty Participating in EML Development Opportunities

Activity	**Time Period**													**FT**	**PT**
E-learning modules – faculty training		S15	F15	S16	F16	S17	F17	S18	F18	S19	F19	S20	F20	35	19
	FT	6	8	1	0	3	2	2	0	2	8	0	3		
	PT	2	7	0	2	3	2	1	0	2	0	0	0		
KEEN Annual Conference	2014	2015	2016	2017	2018	2019	2020	2021						24	0
	2	0	4	4	2	1	7	4							
KEEN FD Workshops	2014	2015	2016	2017	2018	2019	2020							25	0
	9	0	4	3	5	3	1								
EM Champions program	Fall 2019													5	0
Mini-grant program	Fall 2020													10	0
All activities	Spring 2015-Fall 2020													**41**	**19**

Impact of FD Program

Participation in the KEEN FD workshops included the expectation that each faculty participant would develop modules integrating EM into their own courses. Faculty were asked to provide detailed teaching guides so that other faculty in similar fields could leverage the modules and integrate them into their own classes. At first the repository of these modules were simple Google Folders. The web portal, EngineeringUnleashed.com (*EU)*, was established to increase visibility and transferability of the materials developed. To incentivize faculty compliance with these efforts, many of the workshops provided them stipends, a part of which was withheld until satisfactory materials were submitted. More recently, KEEN rolled out an alternate incentive whereby faculty who attend the KEEN Faculty Development Workshops and published their efforts as *EU Cards* were then eligible to apply for recognition and additional funding (known as *EU Fellows).* Of the 25 faculty that have participated in these efforts, 18 report embedding EM into at least one of their courses; 24 *EU Cards* related to these efforts have been published; and one faculty has been recognized as an *EU Fellow*. Student feedback on surveys related to EML are more positive in recent years compared to earlier years as reflected in the sample data shown in Table 3, and we believe this is largely due to increased faculty engagement and positivity related to EML.

Table 3 Average Student Ratings Related to E-learning Modules

Question	**2015*** (***n*** **= 98)**	**Fall 2020*** (***n*** **= 133)**
The instructor reinforced what you learned in the e-learning module through an assignment or a project	3.58	3.95
The assignment or the project was effective in reinforcing what you learned in the e-learning module	3.44	3.91
I found the e-learning module of value	3.33	3.65

* 5-point scale (with 5=highest, and 1=lowest)

Examples of Course Implementations Resulting from FD

Our most recent and focused components in the FD efforts were the EM Champions and mini-grant programs described earlier. Examples of EML implementations resulting from these two programs are presented in this section. As seen in the examples, EML is driven by the emphasis

on the 3C's and is presented in the courses not as an add-on but as an integral component of the material covered to help students learn the technical skills and knowledge required in their disciplines. The EM Champions and mini-grant programs provided the necessary means and support to faculty members to integrate EML in their courses. However, the development of faculty members' interest in and teaching skills related to EML were based on the broad array of FD opportunities provided.

Example 1: Sustainability, Ethics, and Professional Practice

Sustainability, Ethics, and Professional Practice is a course that most engineering students take during the sophomore year or later at the University of New Haven. The course is divided into 14 modules of which 10 focus on the different engineering aspects of sustainability. The course was originally developed with a theoretical term project of greening the engineering building by reducing the energy carbon footprint through passive design of the building and incorporating different renewable energy sources. While the term project was successful, student feedback suggested that the project was too prescribed and they desired more freedom.

When the opportunity to attend a KEEN summer workshop arose, the instructor of the course chose the "Making with a Purpose" workshop to learn about different technologies available in makerspaces (e.g., laser cutting, 3D printing, etc.) and to define a new hands-on and student-focused term project for the course. The instructor was familiar with the EPA-P3 student competition that focuses on design solutions for a sustainable future and provides a hands-on learning experience. Based on the EPA-P3 model, a term project related to people, prosperity, planet, curiosity, connections and creating value (P3-C3) was introduced in fall 2019.

In the new term project, groups of 3 to 4 students worked for nine weeks to create a device that addressed a real-world challenge in a rural community in any part of the world addressing people's health, prosperity, and protection of the planet. The term project deliverables were structured into four sequential stages: (1) a two-page proposal (2 weeks) that needed to be approved by the instructor; (2) design plan and proof of concept paper (3 weeks); (3) prototype production (3 weeks); and (4) final presentation and submission of a design report (1 week).

Students need to be curious about sustainability issues, especially in rural communities around the world, to define a realistic project. Students need to connect their disciplines with other engineering disciplines and learn how to leverage what they learned in previous courses. Students need to be able to identify who they are helping and how the project creates value, which can be monetary, societal benefits, environmental benefits, etc. The new project was designed to be open-ended (addressing previous feedback from students), multi-disciplinary (to appeal to students from multiple engineering disciplines), and hands-on (to align with the experiential learning mission of the college). The first implementation of the project was very successful. Four groups of four students created very different prototypes addressing different sustainability needs.

In spring 2020 two modifications were added to the project. The first one was about the project topic selection. The revision required each individual student to submit a two-page proposal, all members to present their ideas, and collectively select the best idea considering the instructor's feedback. The second modification was to reduce variation in project scopes and makerspace

technologies used. Some of the fall 2019 projects were as simple as a solar refrigerator, and others as complex as a green tower with automatic rain collector and distributor. In the modification, the prototypes were restricted to not be larger than 30″× 30″× 30″ in size, and depending on the number of students in the group, technologies such as 3D printing, laser cutting, hand tools and some simple programing and automation such as with Arduino were required in producing the prototype. The details about this activity can be found at https://engineeringunleashed.com/card/158.

Example 2: Statics

After learning the Problem Solving Studio (PSS) pedagogy by attending a KEEN sponsored workshop in August 2019, the instructor applied PSS extensively in both on-ground and remote delivery methods for over 5 course sections — with a special emphasis on the sophomore Statics course. The PSS pedagogy has students collaborate in teams of two while performing a class exercise (e.g., engineering practice problem), while the instructor observes and offers guidance to the teams. PSS is distinguished from typical team collaboration in that both students work from only one (large) sheet of paper with only one pencil. One student illustrates while the other collaborates and guides. The student guiding experience enhances the deeper learning from teaching others. The previous class activity periods were very useful in enabling students to practice and to easily ask the vital questions while all parties were present. PSS enhances this learning by the added pedagogy of student collaboration with active instructor guidance and learning through guiding. PSS also models a successful student homework group setting, thereby further advancing students' learning skills.

With the collaboration and instructor support, students more rapidly learn applications of complex topics that require a significant amount of trial and error. PSS helps students learn to persist through and learn from failure in a non-threatening activity, thereby learning and reinforcing the behaviors which support the EM component of creating value. Students are expected to generate their own solution(s) to a sample problem as their deliverable to themselves. Students' work from the PSS is not kept or graded by the instructor so as to reinforce an open and non-threatening environment where risk taking and learning from failure is encouraged.

PSS is best applied in a class with additional, designated class activity or recitation time. In our college, many common, lower division courses have a 75-minute lecture followed by a 25-minute class activity period. Depending on the specific topic, a class activity with PSS will take between 30 and 45 minutes. Teams of two students are either self or instructor assigned. The instructor introduces the exercise (e.g., sketching a free-body-diagram of a complex mechanics problem), and the teams begin working with their one large sheet of paper (e.g., 11"x17"). Only one student illustrates with the one pencil while the other student team member guides for about 10 minutes and then teams are asked to swap the pencil. For remote delivery, student teams work in virtual breakout rooms and share a common web-based digital file (e.g., PowerPoint). During the spring 2021 semester, both students and instructor have a digital stylus to best enable the learning of the abstract graphics which are vital to statics. Both the breakout rooms and shared files are visited/editable by the instructor. The instructor is available to answer questions. Additionally, a key instructor role is to actively observe the teams' work and offer specific guidance (for example) when a team can't quite formulate a question. If the instructor's

observation reveals that many teams are "stumped" on one element, the instructor will call all teams' attention and offer class-wide guidance to get the teams back on-track. One instructor can typically manage up to about 7 teams; teaching assistant help is recommended for larger sections. The details about this activity can be found at https://engineeringunleashed.com/card/2677.

Example 3: Electrical Power Systems Course

After attending an ICE Workshop in Summer 2015, the instructor has been actively integrating EML in the senior course by designing course projects that solve practical problems and creating modules to help students identify and use resources to solve these problems. In this implementation, the instructor designed a new module to encourage students to evaluate advancements in technology with an economic perspective and critical thinking in addition to technical analysis in an Electrical Power Systems course that covers fundamental principles in the power and energy discipline.

The need to develop low-emission and alternative energy resources is driving the construction of wind and solar generation all over the country. Large penetration of the new generation forms is changing the landscape of the power industry and instructors need to incorporate new knowledge to power system courses. To foster EML, a new module was added to the course to discuss revolutionary economic and market changes in the power industry caused by renewable energy. In the module, students were introduced to: (a) the shrinking revenue that utilities are facing because the renewable generation reduces their electricity sales; (b) the business innovations that are emerging to take advantage of the new generation forms; and (c) cost-benefit analysis of investing a renewable generation station. Moreover, a team project was tied to the module in which the students were asked to perform a cost-benefit analysis of building renewable power plants, explore the market solutions to develop renewable energy generation, and present and submit their analysis report. The module was carried out in three stages:

Stage 1: Three-hour in-class lecture. This stage was for raising awareness and delivering essential knowledge and skills around energy economics.

Stage 2: Out-of-class group discussion and design formation. This stage included a half-hour meeting with the instructor to discuss designs and ask questions.

Stage 3: Project presentation, and one week later, submission of a project report that addresses the feedback received during the presentation.

In the project, students were asked to select a location in the U.S. to develop a photovoltaic (PV) generation system, a wind farm, or a hybrid generation system. The project work included cost-benefit analysis, the period of return, and the investment rate of return of the new generation station calculations. The presentations covered the project topic, development process, economic analysis, calculations, observations, and conclusion. The details about this activity can be found at https://engineeringunleashed.com/card/2546.

Example 4: Sustainability and Innovation in the Field of Engineering Hydrology

The instructor of this course was first exposed to the 3C's at an ICE Workshop. The work resulting from this participation consisted of two EML-based modules for a water resources engineering course, with a specific focus on increasing student motivation to learn via the 3C's philosophy. These modules have gone through several years of deployment in the specified

course and greatly enhanced student engagement and motivation. The EML module described below is the most recent effort of this instructor.

This Engineering Hydrology course in which EML is implemented is a course that both undergraduate civil engineering and graduate environmental engineering students take. The EML activity was a new project completed in teams. The project work guided students to explore the ways sustainability considerations and innovation impact the field of engineering hydrology with a special aim to increase student's curiosity. Students were asked to explore case studies, technical papers and reports, news items, design manuals, and any other pertinent resources to find examples of sustainable innovation related to this field and to find the next big ideas that could help cultivate the mentality of innovation and the commitment to use sustainable engineering practices in engineering hydrology. The goal was to help students develop a "toolbox" of possible innovative technical solutions that have the potential to significantly reduce adverse human impacts on the climate and to inspire them to become agents of change who will be instrumental in addressing the grand challenges that humankind currently faces through the pillars of innovation, creativity, and engineering ingenuity.

This exercise helped students in making connections between the field of engineering hydrology and the broader societal context where engineers perform their work. The project also encouraged students to think about the value created by water resources engineers through improved quality of life and increased use of sustainable practices in society. In addition, since the project work was completed in teams of two, students also had an opportunity to practice their collaboration and communication skills through teamwork. The project also served as a student engagement tool throughout the semester. This was especially critical in fall 2020 when the course was delivered in a remote synchronous mode. The project lasted for twelve weeks and it consisted of a mixture of in- and out-of-class activities.

Overall, the project was well received by students and the associated activities did increase student engagement with the course content. The project deployment format was very beneficial in the online delivery mode of the course as it contributed to the variety of active learning strategies employed during class meeting times that helped hold students' attention. The project is also easily scalable for individual work, or for larger teams. Finally, the open-endedness of the topic could be streamlined if desired by setting themes for the items that students need to explore. The details about this activity can be found at https://engineeringunleashed.com/card/2693.

Summary and Conclusions

We described the faculty development efforts carried out at a medium-sized engineering college to help faculty embrace and practice EML. The initial efforts were designed to address immediate needs which focused on developing EM in all engineering and computer science undergraduate students. These efforts consisted of internal trainings that provided an overview of EM and external workshops and conferences that aimed to equip faculty with effective EM pedagogical techniques. A large number of faculty were involved in these initiatives and played a role in implementing EML in the college. However, sustaining their involvement and motivating them to develop their own EML activities proved to be difficult as faculty responsibilities and interests changed. It became apparent that a structured and targeted approach

was needed to enhance faculty interest in EML and make it a part of the culture in the college. Two internal programs were launched in this context. The first program developed champions to promote and support EML within their programs; the second program provided mini-grants to faculty to more broadly deploy EML.

The participation data from the early initiatives, faculty interest for the more recent programs, and the products generated from all these connected opportunities indicate that faculty are now more strongly engaged in EML related curricular and extra-curricular activities. Stronger faculty engagement also resulted in students' perceptions toward EML being more positive; their feedback to surveys were more positive in recent years compared to earlier years.

References

1. Y. Steinert (Ed.), *Faculty development in the health professions: A Focus on Research and Practice*. Springer Netherlands, 2014. 10.1007/978-94-007-7612-8.
2. Y. Steinert, R.L. Cruess, S.R. Cruess, J.D. Boudreau, and A. Fuks, "Faculty development as an instrument of change: a case study on teaching professionalism." *Academic Medicine: Journal of the Association of American Medical Colleges*, vol. 82, no.11, pp. 1057-1064, 2007. doi:10.1097/01.ACM.0000285346.87708.67
3. C.E. Christianson, R.B. McBride, R.C. Vari, L. Olson, and H.D. Wilson, "From traditional to patient-centered learning: curriculum change as an intervention for changing institutional culture and promoting professionalism in undergraduate medical education." *Academic Medicine : Journal of the Association of American Medical Colleges* vol. 82, no.11, pp. 1079-1088, 2007.doi:10.1097/ACM.0b013e3181574a62
4. R.M. Felder, and R. Brent, "The National Effective Teaching Institute: Assessment of impact and implications for faculty development." *Journal of Engineering Education*, pp.121-134, April 2010. doi:10.1002/j.2168-9830.2010.tb01049.x
5. D. Carpenter, and G. Feierfeil, "Cultivating an entrepreneurial mindset through interdisciplinary collaboration and networking." Proceedings of the 114th ASEE Annual Conference & Exposition, Honolulu, Hawaii, June 24-27, 2007, https://peer.asee.org/2419.
6. W.M. Jordan, C.C.Fry, and K.W. Van Treuren, "Promoting the entrepreneurial mindset through faculty development." Proceedings of the 123rd ASEE Annual Conference & Exposition, New Orleans, LA, June 26-29, 201. https://strategy.asee.org/260077.
7. H. Dillon, L.H. Mayled, M.L. Nagurka, M. Carnasciali, and D.E. Melton, "Intercollegiate coaching in a faculty professional development program that integrates pedagogical best practices and the entrepreneurial mindset." Proceedings, ASEE Virtual Annual Conference Content Access, Virtual On line, June 21-24 2020. https://strategy.asee.org/34860.
8. KEEN, "What is the KEEN Framework?," https://www.engineeringunleashed.com/Mindset-Matters/Framework.aspx. [Accessed May 17, 2021].
9. N.O. Erdil, R.S. Harichandran, J. Nocito-Gobel, M.Carnasciali, and C.Q. Li, "Integrating e-learning modules into engineering courses to develop an entrepreneurial mindset in students." Proceedings of the 123rd ASEE Annual Conference & Exposition, New Orleans, LA, June 26-29, 2016. https://strategy.asee.org/25800.
10. N.O. Erdil, R.S. Harichandran, J. Nocito-Gobel, C.Q. Li, M. Carnasciali. "Impact of Integrated E-Learning Modules in Developing an Entrepreneurial Mindset based on Deployment at 25 Institutions." Proceedings of the 124th ASEE Annual Conference & Exposition, Columbus, Ohio, June 24-28, 2017. https://peer.asee.org/28467.