Introduction to Entrepreneurial-minded Learning for Faculty of Foundational STEM Courses Using the KEEN Framework

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Dr. Sabick's research areas are orthopedic biomechanics and sports medicine. Her primary focus is on how highly ballistic human movements affect the joints of the upper extremity. She is the President-Elect of the American Society of Biomechanics and the co-chair of the Saint Louis University Science and Engineering Task Force.

Throughout her career, Sabick has been passionate about improving undergraduate engineering education. She has been highly involved in efforts to transform STEM teaching practices at both Saint Louis University and Boise State, where she helped mentor faculty members to infuse courses with more interactive and hands-on learning experiences. She is currently working on a Boeing-funded project to infuse more math content into the middle school curriculum in the St. Louis Public School System.

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Introduction

Attrition rates in engineering and other STEM disciplines as a whole hover around 50% nationally. Numerous initiatives have tried to improve those numbers while better preparing STEM graduates for the workforce. One initiative in particular is the Kern Entrepreneurial Engineering Network (KEEN), which strives to complement the technical skills of engineering students with an Entrepreneurial Mindset to create more well-rounded engineering students. Saint Louis University (SLU) is a member of KEEN and has spent several years implementing the Entrepreneurial Mindset across its Parks College of Engineering, Aviation and Technology, specifically in its engineering programs. SLU recently began a new initiative in partnership with KEEN to work with other STEM disciplines on campus to incorporate the Entrepreneurial Mindset in foundational STEM courses by creating opportunities for STEM faculty to learn more about KEEN and the Entrepreneurial Mindset, and how it can be integrated into their courses. SLU held a two-day STEM Faculty Teaching Institute in January of 2018. The purpose was to expose STEM faculty to various evidence-based teaching practices, along with the entrepreneurial-minded learning (EML) framework, and to encourage participating faculty to submit medium-sized Program Transformation Grant proposals to help spread EML implementation throughout their home departments. The specific objectives were to:

1. Familiarize faculty with active and entrepreneurial minded learning techniques that could be infused into a course of their choosing.
2. Examine the connections between math, the sciences, technology, and engineering, so faculty will be able to help their students make those connections in all their classes.

This paper provides a brief overview of KEEN, the rationale for the project, and a detailed summary of the Teaching Institute. Additionally, the paper also includes a summary of feedback data generated from pre- and post-surveys given to the participants and an overview of the Program Transformation Grants initiative. Lastly, the paper includes some lessons learned and provides some insight on how the project will move forward in the future.

Kern Entrepreneurial Engineering Network

The Kern Entrepreneurial Engineering Network (KEEN) currently includes 37 partner institutions that are dedicated to embedding the Entrepreneurial Mindset within their undergraduate engineering programs. Engineering students develop a skillset as they progress through their curriculum that primarily revolves around technical skills such as analysis and design. While these skills are important, students also need a mindset to augment their toolbox of skills necessary to become outstanding engineers. The Entrepreneurial Mindset "equips engineering students to understand the bigger picture, allowing them to recognize opportunities, evaluate markets, and learn from their mistakes." [1] KEEN developed a framework for the Entrepreneurial Mindset. The KEEN Framework is a supplement to the technical skills students already learn in their courses and revolves around the 3 C's: Curiosity, Connections, and Creating Value. KEEN defines each of the 3 C's. Curiosity is the ability to "demonstrate constant curiosity about our changing world and to explore a contrarian view of accepted solutions;" Connections is the ability to "integrate information from many sources to gain insight and to assess and manage risk;" and Creating Value is the ability to "identify unexpected opportunities to create extraordinary value and to persist through and learn from failure." The historical focus of KEEN has been on engineering programs, but many engineering and STEM students lose interest in their majors while enrolled in foundational STEM courses, where course sections are often very large, and success rates are often well below campus averages.

Project Rationale

Attrition rates of undergraduate engineering students consistently hover around 50% throughout the United States [2-11]. Geisinger and Raman [2] conducted an extensive literature review on student attrition and retention including 50 and 25 studies, respectively. They concluded that six factors contributed to students leaving engineering: classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, high school preparation, interest and career goals, and race and gender. Furthermore, a 2013 report [11] by the Institute of Education Sciences (IES) reinforces Geisinger and Raman's conclusions. The report notes that STEM attrition correlates with student demographics, high school preparation, type of institution, and STEM courses taken and performance. However, the results showed stronger correlation between attrition and the intensity of STEM courses, the type of math courses, and the level of success in STEM courses more so than other factors. The report also notes that less success in STEM courses compared to non-STEM courses correlated with increased probability of dropping out of college. While high school preparation and race and gender are beyond the scope of this paper, classroom and academic climate, grades and conceptual understanding, self-efficacy and self-confidence, and interest and career goals may be directly or indirectly impacted by this work.

Active learning is as an instructional method that engages students in the learning process using meaningful, more in-depth learning activities [12], in which students take ownership of their learning experience [13]. Prince and Felder [14] list a number of active learning methods, including inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching. The primary objectives of active learning are to promote student activity and to engage them in the learning process [15], in-turn changing the classroom environment. Several studies discuss the link between self-efficacy and self-confidence and pursuit and persistence towards an engineering degree [2, 7, 16-30]. In short, students with low self-efficacy and self-confidence are less likely to persist in science and engineering compared to their peers with higher levels of self-efficacy and self-confidence [2]. Gleason et al. [31] found a strong correlation between math placement and retention rates in engineering. They found that students who placed in College Algebra or below accounted for only 10% of engineering graduates and those who placed in Pre-calculus accounted for nearly 40% of dropouts. Likewise, Santiago and Hensel [32] found that 34% of students who left engineering due to academic difficulties noted specific difficulty with Calculus I. Students take longer to complete core requirements when they fail to place into Calculus I or above, which increases the possibility of them leaving engineering.

Additionally, students often struggle to see the connections between foundational STEM courses and their future careers. In fact, the first two years of most engineering students' curriculum is predominantly foundational STEM courses. Fig. 1 shows the first two years of the Biomedical Engineering curriculum at SLU. All of the courses shown in white are foundational STEM courses, which make up 61% (37 of 61 credit hours) of a Biomedical Engineering student's first two years. In other words, 61% of the time students are typically learning theoretical information with very little application to their major. Science and Mathematics are essentially the foundations of engineering. Without a firm understanding of science and math and the confidence to persist through such subjects, engineering is not feasible. The hypothesis is that student retention in engineering can be improved by better engaging them in their foundational STEM courses and improving their self-efficacy and self-confidence by creating obvious connections between those courses and their engineering majors. While the primary objective is to improve retention rates of engineering students, better engaging all students in foundational STEM courses could improve retention rates across all STEM disciplines. This project aims to improve both student performance and engagement in foundational STEM courses by working with faculty members across STEM disciplines to infuse elements of evidence-based teaching practices and EML.

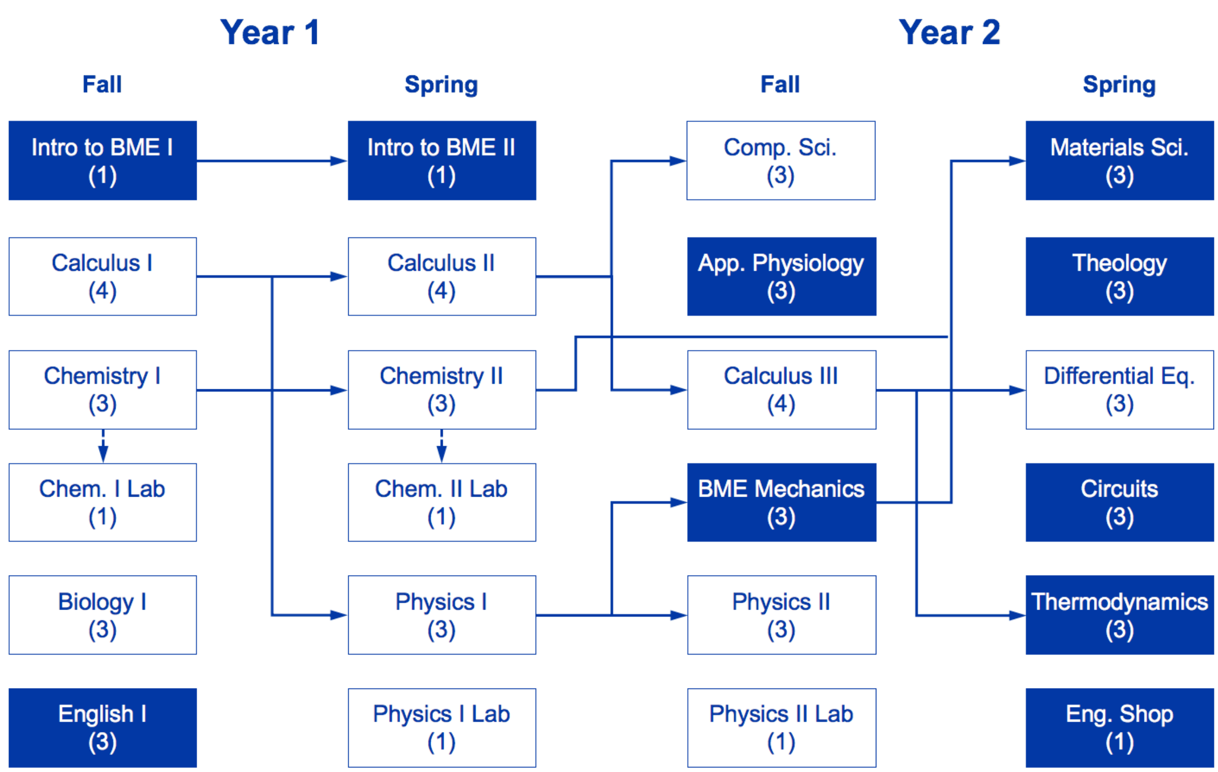


Fig. 1— Sample first and second year Biomedical Engineering Curriculum at SLU

One of the most widely known professional development opportunities focused on the Entrepreneurial Mindset is the KEEN Innovating Curriculum with Entrepreneurial Mindset (ICE) Workshops. The ICE workshops "…introduce faculty to the framework of entrepreneurially minded learning (EML) centered on curiosity, connections, and creating value.

Participants learn about a variety of different active learning techniques that can be applied to instill the Entrepreneurial Mindset in students. Participants also learn about key components for making a strong learning experience for their students including learning objectives, problem statements, and teamwork…" [33]. Another approach at Baylor University [34] builds upon the ICE workshops with monthly lunchtime seminars along with "End-of-semester Faculty Development Workshops" and an "Internal Grant Program: the KEEN Innovators Program." The purpose of the Innovators program is to encourage faculty to integrate entrepreneurial concepts in their courses through stipends supporting the development of modules. The duration of the module can be from 15 minutes up to two hours in length and the modules are packaged for dissemination. While there are existing professional development opportunities that instill the Entrepreneurial Mindset in engineering courses, no such program exists for non-engineering, foundational STEM courses. This project used an approach with aspects similar to both the ICE Workshops and the Baylor program, but rather than focus solely on engineering faculty, the workshop included faculty from across all STEM disciplines, in particular those from core foundational courses such as Calculus, Chemistry, Biology, and Physics.

STEM Faculty Teaching Institute

The STEM Faculty Teaching Institute (Teaching Institute) was a two-day workshop that included 20 faculty participants from seven different disciplines: Aviation Science (2), Biology (4), Chemistry (3), Computer Science (2), Engineering (5), Mathematics (3), and Physics (1). The Teaching Institute was held in conjunction with the Reinert Center for Transformative Teaching and Learning (Reinert Center) at SLU, and used the Reinert Center's Learning Studio classroom. The Learning Studio comfortably seats 20 individuals and provides an interactive learning environment by utilizing mobile furniture. Prior to the Teaching Institute, participants were asked to complete the registration process on KEEN's website, EngineeringUnleashed.com; view three short videos introducing them to KEEN, the 3C's, and the value of EML; take the Index of Learning Styles Questionnaire, [35] and send their questionnaire results to the workshop organizers. Participants were divided into five groups consisting of four faculty members each for the Teaching Institute, such that each table had faculty from four different disciplines. Table 1 shows the full itinerary for the Teaching Institute.

Table 1—STEM Faculty Teaching Institute Itinerary

Day 1

Time	Session	Objectives
9:00 am	Welcome and Introductions	Become familiar with cohort and workshop objectives
9:30 am	KEEN Opening Remarks	Understand the role and mission of KEEN
10:00 am	Introduction to Active Learning Modules	Discover the differences in learning styles and examine active and entrepreneurially minded learning techniques in a lecture format
12:00 pm	Working Lunch	Work on course development module design within your cohort
12:45 pm	Keynote	Distinguish how adult cognition works and examine how and why what we do in the classroom impacts our effectiveness as teachers
2:00 pm	Introduction to the Reinert Center	Understand the role the Reinert Center on campus and describe its available resources and examine course mapping techniques to help students and faculty make connections
3:00 pm	Working Reception	Network with members of other cohorts and the leadership team to discuss ideas for specific course development modules
4:00 pm	Adjourn	

Day 2

Time	Session	Objectives
9:00 am	Incorporating Entrepreneurship and Innovation into the Classroom	Understand the concept of the academic entrepreneur and identify how research active faculty (especially those who pursue grants) already have many of the skills needed as an entrepreneur
10:00 am	Value Creation Mindset	Examine a revenue-neutral conception of value and demonstrate a two-matrix model of evaluating value for their students
11:30 am	Peer Review of Course Development Modules	Obtain feedback from cohort members on your course development module
12:00 pm	Working Lunch	Work on course development module design within your cohort
1:00 pm	Modules of Engineering Concepts in STEM Courses	Experience specific examples of how to integrate engineering concepts into other STEM disciplines and examine more active and entrepreneurially minded learning techniques
2:45 pm	Intro. to Program Transformation Grants	Become familiar with the internal grant submission process and objectives
3:15 pm	KEEN Closing Remarks	Learn about the future direction of KEEN, and other activities and opportunities within the network
4:00 pm	Adjourn	

Day 1—Welcome and Introductions and KEEN Opening Remarks

The Teaching Institute began with some brief introductions and an overview of the schedule followed by a Carousel activity. Eight mobile whiteboards were placed around the room, each containing one of eight terms: Engineering, Technology, Entrepreneur, EML, Active Learning, Curiosity, Connections, and Creating Value. Participants were asked to write their interpretation of each term on that respective whiteboard. Fig. 2 shows the results of that activity in the participants own words. Following a brief discussion of the responses, a KEEN representative used the results from the Carousel activity as a segue into an overview of KEEN and a brief discussion of the Entrepreneurial Mindset including the core principles of the 3 C's.

Engineering
- Focused
- Problem solving
- Utility
- Find solutions to an idea
- Create new or improved product
- Building useful devices
- Bring ideas to fuition
- Theoretical
- Designing
- Use of math and science

Technology
- Innovation
- Progress
- Practical application
- Customers
- New or improved products
- Tools
- Supportive
- Shiny gray
- Humane

Entrepreneur
- Startup
- Novelty
- Funding
- Lean development
- Market
- Project planning
- Networking
- Persistent/driven
- Value of failing fast
- Risk
- Business
- Innovative

Entrepreneurial Mindset
- Thinking modern
- Be bold
- Motivated
- Optimistic
- Risk taker
- Intrapreneur
- Money
- Extensions
- Find your customer
- Find value

Active Learning
- Participation
- Movement
- Always asking "why" "how"
- Student works/thinks through problem on own or with limited help
- Engagement
- Fun learning
- Application
- Leaning in a group
- Building (Hands-on)
- Hands-on Interactive Learning
- Curiosity
- Level Playing Field

Curiosity
- Ask questions
- Solve problems
- Willingness to fail
- Come up with steps to solve a problem
- Extending a concept
- Questioning
- Discovery
- Digging deep
- Active learning

Connections
- Network with others
- Integrate different disciplines
- Context
- Relate knowledge for different courses
- Understanding customers
- Play nice
- Organizing
- Contextualization
- Connect concepts from course to another field

Creating Value
- Application to today
- Think of where it can be used
- End customer
- Empathy
- "Why do I care?"
- Addressing a market need
- Social impact
- Payoff
- Marketable
- Intellectual stimulation

Fig. 2—Carousel Activity Results

Day 1—Introduction to Active Learning Modules

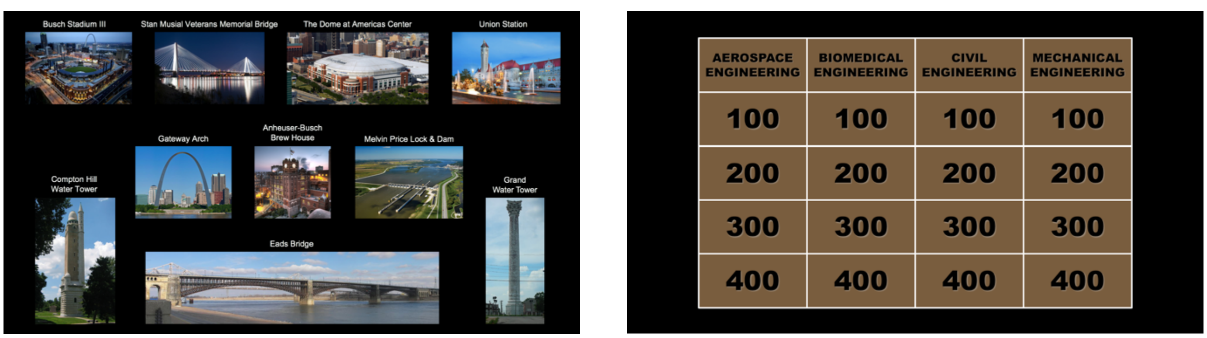
The depth of pedagogical knowledge varied widely among faculty participants. So, the first session of the Teaching Institute focused on an introduction to learning styles, active learning, and entrepreneurial minded learning. Of the 20 faculty participants, 19 took the Index of Learning Styles Survey and submitted their results prior to the Teaching Institute. The results were summarized and presented to the participants along with a brief overview of what the results mean and how they compared with engineering students. The results showed that the faculty participants tended to prefer a more reflective than active learning style, a more intuitive than sensory learning style, a more visual than verbal learning style, and were essentially neutral with regard to preferring a sequential or global learning style. Comparison data from engineering students provided contradictory learning styles preferences. Students tend to prefer more active than reflective learning styles, more sensory than intuitive learning styles, and a more sequential than global learning style. The only category where faculty participants learning styles preferences aligned with engineering students' learning styles preferences was the visual versus verbal category. The purpose of the comparison was to illustrate the differences among faculty and students and to point out that the way faculty members prefer to learn may not align with the majority of their students' learning styles and that faculty may need to adjust their teaching styles to accommodate more of their students' learning preferences. A number of active learning strategies were presented at the Teaching Institute. Table 2 lists the active learning strategies along with perceived preparation and complexity levels. Those highlighted in blue were the ones used in the Teaching Institute with faculty participants. The EML discussion revolved around mindset and the 3 C's. Bosman and Fernhaber [36] state that "Your mindset is the sum of your knowledge, including beliefs and thoughts about the world in it… Mindset determines how you receive and react to information." They go on to note, "Fixed mindset believes your talents and abilities are set; growth mindset believes your talents and abilities can be developed." Participants were introduced to the growth mindset concept and that they can directly influence the mindset of their students through the experiences they provide within their classes.

Table 2—List of active learning strategies presented

	Active Learning Strategy	Preparation	Complexity
General	Minute Paper	Low	Low
	Muddiest Point	Low	Low
	Classroom Opinion Polls	Low	Low
	Assignment Assessment	Low	Low
	Application Cards	Low	Low
	One-sentence summary	Low	Low
	Punctuated Lectures	Low	Low
	Teacher-designed Feedback Forms	Low	Low
	Think-Pair-Share	Low	Low
	Drawing for Understanding	Low	Low
	Background Knowledge Probe	Low	Low
	Process Analysis	Low	Medium
	Recall, Summarize, Question, Connect, and Comment	Low	Medium
	Peer Discussion	Medium	Medium
Advanced	Inquiry-based Learning	Low	Low
	Case-based Teaching	Low	Low
	Discovery Learning	Low	Medium
	Just-in-time Teaching	Medium	Low
	Problem-based Learning	Medium	Medium
	Game-based Learning	High	Low
	Project-based Learning	High	High
	Experiential Learning	High	High
	Service Learning	High	High

Throughout the Teaching Institute, the authors used the highlighted active learning strategies with the participants to illustrate their use in the classroom. The first illustration was the summary of learning styles previously discussed. The results were compiled the night before the Teaching Institute and were used in the discussion on the morning of Day 1 to illustrate

"Just-in-time teaching." The second illustration featured "Peer Discussion," which requires participants to discuss a given problem and share their ideas with the larger group. The learning objectives for the activity were to develop team dynamics within their cohort and to generate curiosity within the group. Participants were presented with 10 St. Louis structures shown in Fig. 3 (a) and were directed to order them from oldest to newest individually without any electronic assistance. After ranking the structures individually, participants were then directed to pair up and collectively rank the structures from oldest to newest. Lastly, participants were asked to develop a general consensus on the rankings for their cohort at each respective table. After each cohort had come to a general consensus, the presenter revealed the actual rankings and discussed the results with the whole group. Immediately following the peer discussion activity, the participants were led into the third illustration featuring a "Think-pair-share" activity. The learning objective of the activity was to identify the connection between the sciences, math, and engineering. Participants were asked "What part do math and the sciences play in the design of engineering structures.?" Each individual developed his or her own answer and then shared with the cohort, before one individual reported out for each cohort. The third illustration of active learning strategies featured "Game-based learning," which is a type of game play that has defined learning outcomes. The learning objectives for the activity were to identify the given structure and explain how the engineering structure creates value. The presenter created a Jeopardy-style game with four categories: Aerospace Engineering, Biomedical Engineering, Civil Engineering, and Mechanical Engineering. Fig. 3 (b) shows the game board. Each participant had an iClicker2 remote and had the opportunity to "buzz in" to answer each of the 16 questions for their respective cohort. At the conclusion of the game, participants were introduced to the "minute paper" through a final question, "What role does your discipline play in creating value in engineering?"



(a) (b)

Fig. 3—(a) Peer discussion slide and (b) Jeopardy board.

The last illustration of active learning strategies featured "Experiential Learning," which requires participants to apply their knowledge and conceptual understanding to a real-world problem and assess their decisions through the reflection process. The learning objectives of the activity were to realize the importance of economic design, understand the difference between problem-based, project-based, and experiential learning, and to explain how their design creates value. Participants were tasked with building a K'Nex Tower that was structurally stable, minimized disturbance to the environment, optimized the user's viewing experience, and was most cost efficient. Each tower was required to support 8 kg (17.6 lb) and was evaluated using Equation (1). Fig. 4 (a) and (b) shows one cohort of faculty constructing their K'Nex tower and then load testing it, respectively. The purpose of the selected sequence of activities was twofold: 1) to introduce participants to various active learning strategies and 2) to show participants the connections between math, science, and engineering and how each discipline contributes to value creation in some form.

$$Score = \frac{\sum_{i=1}^{n} P_i h_i^2}{AW} \qquad \text{Eq. (1)}$$

Where,

- i = floor number
- n = total number of floors
- P = perimeter of floor (in.)
- h = height of floor measured from the ground (in.)
- A = footprint area of the tower (in.^{2})
- W = weight of the tower (lbs)

(a) (b)

Fig. 4—One group of participants (a) builds their K'Nex tower and (b) load tests their tower.

Day 1—Keynote Speaker

Day 1 featured a Keynote speaker immediately following lunch. The objectives of the presentation were to distinguish how adult cognition works and examine how and why what we do in the classroom impacts our effectiveness as teachers. The speaker began with a brief discussion of "What is effective teaching?" and noted that what we teach and how we teach it are linked and are very much dependent on each other. The speaker also discussed principles of good practice in undergraduate teaching, principles of good course design, and characteristics of learner-centered teaching before defining cognition and discussing its multiple processes. Lastly, the speaker posed the question, "How does all this translate to teaching effectiveness?" In response, the speaker discussed motivation and influencing motivation as well as guidelines for facilitating learning.

Day 1—Introduction to the Reinert Center

The Reinert Center for Transformative Teaching and Learning (Reinert Center) is SLU's teaching center. The mission of the Reinert Center is to develop, encourage, and sustain SLU faculty and graduate students so that they can better serve the intellectual, spiritual, and sociocultural needs of all learners. The Reinert Center guides faculty in the context of Jesuit traditions of education; develops a community of scholars; promotes the integration of technology and other teaching innovations; and advances Ignatian approaches along with improving teaching scholarship. While many SLU faculty know of the Reinert Center, many are unaware of the resources it provides. The objectives of this session for participants was to understand the role the Reinert Center on campus and describe its available resources and examine course mapping techniques to help students and faculty make connections. Reinert Center representatives provided a brief overview of its services to faculty with a particular focus on the Learning Studio and the Innovative Teaching Fellowships they award each year. However, the main focus of their session was to lead participants through a Course Mapping Activity to help faculty visualize connections and to identify ways to help students create value within their courses. Course mapping also helps faculty build relationships among concepts, scaffolding, the overall learning experiences, and to identify what matters most. The presenters noted that adding priorities like active learning and EML may require a shift: less coverage sometimes leads to more learning. After the introduction to course mapping, the presenters guided participants to first construct a concept map for their course and identify connections. Lastly, the presenters briefly discussed the use of visual syllabi.

Day 1—Working Reception

The objectives of Day 1's last session were to network with members of other cohorts and the leadership team and discuss ideas for specific course development modules. Participants received a homework assignment to complete before returning for Day 2: create a draft module for a particular course that incorporates EML and bring that module for peer feedback.

Day 2—Incorporating Entrepreneurship and Innovation into the Classroom

Day 2 began with a presentation by two representatives from SLU's Entrepreneurship Program. The objectives of the session were to understand the concept of the academic entrepreneur and identify how research active faculty (especially those who pursue grants) already have many of the skills needed as an entrepreneur. The presenters first focused on the notion that many of the activities faculty already do on a daily basis correspond to equivalent activities of entrepreneurs (e.g. grants proposals → business plans). They defined innovation as the creation of new or improved ideas, products, services or processes and that entrepreneurs pursue opportunity by addressing a need. Second, the presenters provided some tips for how to teach entrepreneurship including some pros and cons.

Day 2—Value Creation Mindset

Following the discussion about entrepreneurship and innovation, the next session focused on value creation. The objectives of the session were to examine a revenue-neutral conception of value and demonstrate a two-matrix model of evaluating value for their students. The presenter began with a discussion of the traditional engineering skillset and how a value creation mindset is missing. The presenter provided a real-world example of value creation featuring the "Lucky Iron Fish" [37] and then led the participants through an activity focused on creating value. Lastly, the presenter noted that value is relative, it depends on context and situation, and it has multiple dimensions. However, some value misconceptions are that more features equal more value and that success is only financial.

Day 2— Peer Review of Course Development Modules

Participants were asked to start development of a module on Day 1 for their courses that incorporated EML. Furthermore, they were asked to continue that development as homework and to bring a draft module with them on Day 2 for peer review. The objective of this session was to obtain feedback from cohort members on your course development module. Participants spent time in their respective cohorts discussing each of their modules and getting feedback and additional ideas from their peers.

Day 2—Modules of Engineering Concepts in STEM Courses

Two example modules were created by the authors to illustrate how entrepreneurial minded learning could be implemented in a math or science course. The example biology module focused on a Human Physiology course. The objectives of the module were to understand the basic functioning of the human auditory system and evaluate technologies used to augment hearing loss. First, the module included an overview of the human auditory system including a hearing exercise to illustrate how hearing deteriorates over time. Second, the participants worked through a "Voices in the Crowd" exercise to simulate an individual's ability to recognize conversations in a crowded room. Within each cohort, three members were each given a different script to read simultaneously. The fourth member of each cohort was tasked with trying to focus their attention on one of the readings. After each cohort finished the Voices in the Crowd activity, the presenter led the group through a series of questions specific to the readers and the listeners. The Third activity was a "Human Hearing Jigsaw" activity including questions about hearing physiology, the "cocktail party effect," cochlear implants, and hearing aids. Each cohort began in their home groups and were each assigned one of the four topics. The participants for each respective topic worked together to answer a series of questions about that topic. Finally, each cohort reassembled to create a flyer that described the problem and presented a potential solution. Fig. 5 (a) shows participants working on the example biology module. In summary, the example biology module included five active learning strategies: multimedia infused lecturing, case-based teaching, jigsaw/gallery walk, peer discussion, and drawing for understanding.

The example calculus module focused on a Calculus I course. The objectives of the module were to learn about optimization in design and apply calculus concepts to a real-world problem using problem-based learning. The first activity required participants to maximize the amount of corn they could grow within a rectangular plot enclosed by 1,000 ft of fencing. Participants worked within their cohorts to develop an equation for the area of a rectangular plot in terms of "x" and then use calculus concepts to solve for the "x" value that would result in the largest area. The second activity was more open-ended and required participants to optimize the volume of boxes for shipping products. Each cohort received two pieces of 28 in. by 22 in. poster board. The first task was to create a five-sided box with the greatest volume by cutting the same size square from each corner and folding up each side. The second task was to create four smaller boxes out of the second piece of poster board that would serve as gift boxes. At the conclusion of the activity, participants were asked two questions: 1) How did you solve the problem? And 2) How would your students solve the problem? Fig. 5 (b) shows participants constructing their boxes with optimized volumes. In summary, the example calculus module featured problem-based learning and included a follow-up discussion regarding preparation for and the complexity of implementing a problem-based learning activity in class.

(a) (b)

Fig. 5—(a) Participants work through the example biology module and (b) participants construct their optimized boxes for packaging.

Remainder of Day 2

The Teaching Institute concluded with an Introduction to Program Transformation Grants and some closing remarks by the KEEN representative. The Program Transformation Grants were available to any STEM department or academic program that had at least one faculty member on the proposal who had completed the Teaching Institute. Proposals were required to describe a plan to overhaul a course or curricula in a meaningful way to infuse the Entrepreneurial Mindset and student-centered teaching practices. Proposals had to clearly state the project outcomes; articulate specific changes to be implemented, and why these changes were appropriate; describe a process for assessing the results of the project; convey a sustainability plan; and provide a reasonable budget for the given scope of work. Following the Introduction to Program Transformation Grants, the KEEN representative provided some closing remarks about KEEN and the potential impact that EML could have in foundational STEM courses.

Participant Demographics and Feedback

As previously mentioned, the Teaching Institute included 20 faculty participants from seven different disciplines: Aviation Science (2), Biology (4), Chemistry (3), Computer Science (2), Engineering (5), Mathematics (3), and Physics (1). When each participant registered for the Teaching Institute, they were asked five questions pertaining to their classes and active learning. Those questions were:

1. What class sizes do you typically teach?
2. How familiar are you with active learning strategies?
3. How frequently do you use active learning strategies in your courses?
4. How familiar are you with entrepreneurial-minded learning (EML)?
5. How frequently do you use entrepreneurial-minded learning (EML) in your courses?

Following the Teaching Institute, the organizers sent a follow-up survey to all of the participants including 10 questions. Those questions were:

1. Overall, how would you rate this Teaching Institute?
2. How familiar are you with active learning strategies?

3. How frequently do you plan to use active learning strategies in your courses?
4. How familiar are you with entrepreneurial-minded learning (EML)?
5. How frequently do you plan to use entrepreneurial-minded learning (EML) in your courses?
6. How familiar are you with the 3 C's: Curiosity, Connections, and Creating Value?
7. Please rate the following sessions in terms of their value and usefulness to you as a participant?
8. What aspects of the Teaching Institute did you find most beneficial?
9. How will you use what you learned during the Teaching Institute?
10. How might the Teaching Institute have been improved?

Since the initial questions were included with the registration form, all 20 participants answered all five questions. Seventeen of the participants responded to the follow-up survey. Of the 20 participants, seven said they teach courses with 1-15 students; twelve said they teach courses with 16-30 students; seven said they teach courses with 31-50 students; two said they teach courses with 51-75 students; and three said they teach courses with over 100 students. Of the three faculty members that indicated class sizes of 100 or more, two were from Chemistry and one was from Biology. Fig. 6 shows a comparison of the four duplicate questions asked before and after the Teaching Institute.

The majority of participants indicated they were somewhat familiar with active learning strategies and not familiar with EML strategies before participating in the Teaching Institute. After participating in the Teaching Institute, all participants indicated they were very familiar with active learning strategies and nearly all participants indicated they were now somewhat familiar or very familiar with EML. Similarly, fifteen of the participants rated their frequency of using active learning strategies at 3 or 4 before participating in the Teaching Institute where 1 was never and 5 was frequently. On the contrary, 15 participants rated their frequency of using EML as 1 (never) before participating in the Teaching Institute. After participating in the Teaching Institute, 15 of the 17 participations rated their planned use of active learning strategies at 4 or 5, while the remaining two faculty still rated their planned use at 3. Likewise, nine of the participants rated their planned use of EML at 4 or 5 and seven others rated their planned use at 3. The results of the surveys show that participants self-reported increases in level of familiarity for Active Learning Strategies along with EML. The frequency of planned use versus current use also saw significant increases for both Active Learning Strategies and EML.

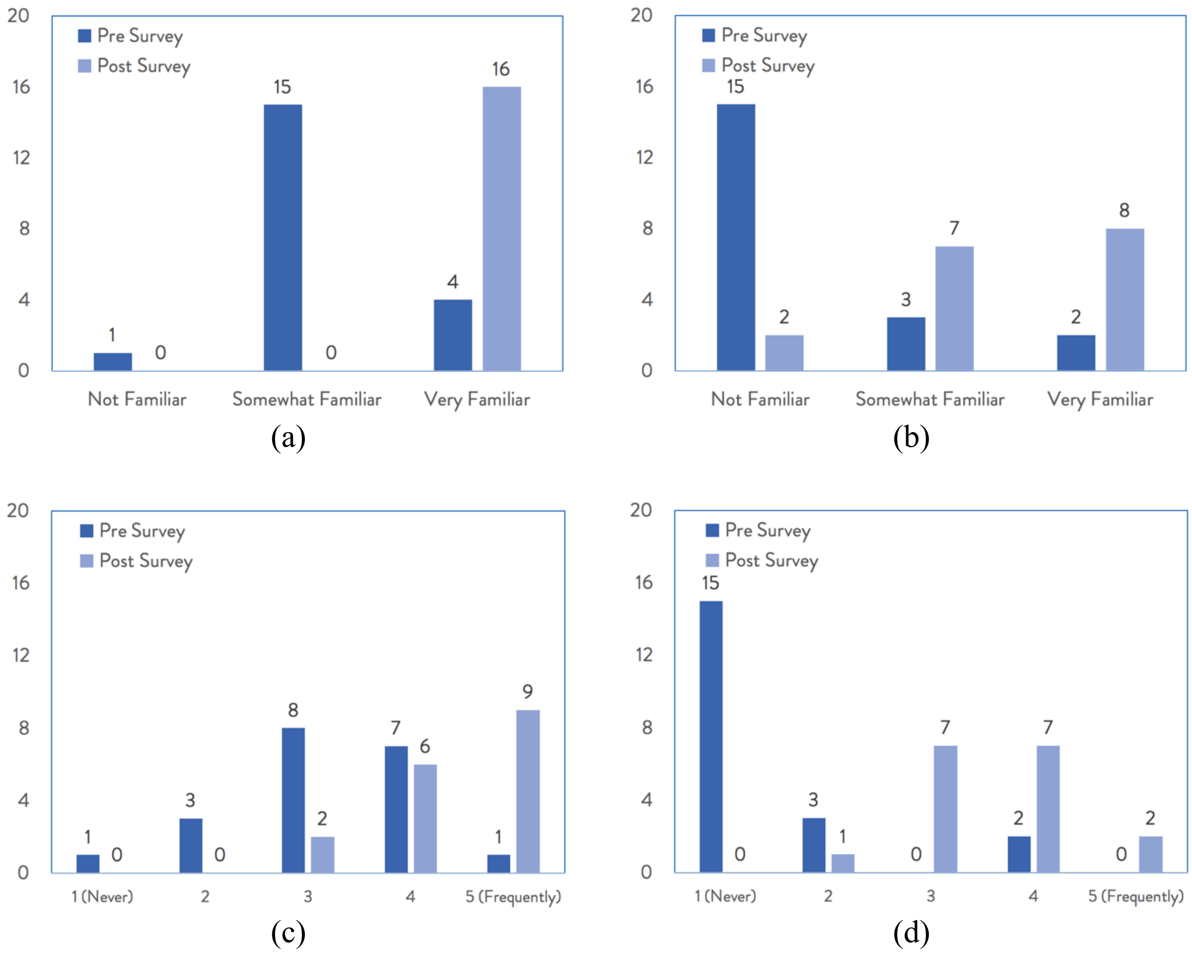


Fig. 6—(a) Active learning familiarity; (b) EML familiarity; (c) active learning use frequency; and (d) EML use frequency.

The overall perception of the Teaching Institute was also of interest to the organizers. When asked how they would rate the Teaching Institute, eight participants rated it as good and nine rated it as excellent. No participants rated the Teaching Institute as poor or fair. Similarly, the organizers were also interested in the participants' perceived level of understanding of the 3 C's and how useful participants found each of the main sessions. Table 3 shows the participants' perceived understanding of the 3 C's. Only 1 participant indicated they were still not familiar with the 3 C's. The majority of the participants felt they were very familiar with the 3 C's, in particular over two-thirds of the participants felt they were very familiar with Creating Value. Similar to their overall perception of the Teaching Institute, the majority of the participants felt that each session was somewhat or very useful. Interestingly, the sessions that utilized the most active learning techniques (Introduction to Active Learning Modules and Modules of Engineering Concepts in STEM Courses) were most useful to participants. In fact, no participants rated either as not useful. The effectiveness of those two sessions were further echoed by the feedback from the open-ended questions.

Table 3—Perceived understanding of the 3 C's

Framework Core Component	Not Familiar	Somewhat Familiar	Very Familiar
Curiosity	1	7	9
Connections	1	6	10
Creating Value	1	4	12

The last three questions on the follow-up survey were open-ended style questions. The first open-ended question, "What aspects of the Teaching Institute did you find most beneficial?" resulted in four themes. First, the participants noted that they liked the seating arrangement with mixed disciplines and the chance to interact with faculty members from across disciplines. Second, the participants felt learning new active learning techniques was beneficial and having time to think about how they could use those techniques in their own respective courses. Third, participants referenced learning how to create value and an Entrepreneurial Mindset in their classes. Lastly, participants noted the live demos by the speakers, in particular the Modules of Engineering Concepts in STEM Courses, which was tagged as the most useful session in Table 4. The second open-ended question, "How will you use what you learned during the Teaching Institute?" resulted in two predominant themes. First, participants noted plans to incorporate more active learning techniques into their courses or continue to use such techniques. Second, a number of participants mentioned incorporating value creation into their courses. Other comments included helping students to connect with a past course, making industry contacts for guest speakers considering value creation, reaching out to others who also use these techniques, and using Course Mapping. The third open-ended question, "How might the Teaching Institute have been improved?" resulted in two primary themes. The most frequent suggestion for improvement was to include more example modules. The second most frequent suggestion for improvement was to provide more time for discussion of modules that participants design along with more one-on-one sessions for faculty to explore new teaching strategies. Other comments included less time doing hands-on activities and more access to different types of hands-on activities, and more University-wide active learning initiatives.

Table 4—Value and Usefulness of six major sessions of the Teaching Institute

Session	Not Useful	Somewhat Useful	Very Useful
Introduction to Active Learning Modules	0	5	12
What Makes for Effective Teaching (and Learning)	3	4	10
Introduction to the Reinert Center and Course Mapping	1	6	10
Incorporating Entrepreneurship and Innovation in the Classroom	3	5	9
Value Creation Mindset	3	7	7
Modules of Engineering Concepts in STEM Courses	0	4	13

Program Transformation Grants

The Program Transformation Grants support projects that have a strong potential to infuse STEM programs or curricula with student-centered teaching practices and EML. Proposals were due on April 1, 2018 and the project periods were set from June 1, 2018 to May 31, 2019. Proposals with high potential for significant transformation were prioritized for funding. Five proposals were funded in full or with partial support with the intention of providing incentive and resources for STEM faculty members to adopt EML in their courses. The long-term goal of this project is to create a community of faculty engaged in EML across the curriculum and enhance the experience and engagement of engineering students. Listed below are brief summaries of the five projects currently underway at SLU.

Tissue Engineering and Regenerative Medicine

The focus of this project is to create a Tissue Engineering and Regenerative Medicine concentration within the Biomedical Engineering curriculum. The scope of the project includes creating four EML focused modules that will engage students and span across two or more disciplines within the BME curriculum, including basic science courses.

Nanotechnology and Nanomaterials

Nanotechnology and nanomaterials is a novel area and touches many different engineering disciplines. This project is a seed grant to develop a module for the Introduction to Engineering course. The module will be piloted in the fall semester throughout the School of Engineering to gauge interest in the area. If successful in this activity, the investigators hope to create additional courses or course content related to nanotechnology and nanomaterials.

Active Learning Modules for EML in Freshman-Level Chemistry Courses

This project aims to affect a broad change across a large number of courses that touch every single engineering and science student at the university. The scope of the project includes 12 EML-focused chemistry learning modules that include process-oriented guided inquiry learning, real-world context, and hands-on activities in high-enrollment courses. Four chemistry faculty members are collaborating on this project that could truly transform introductory chemistry for all STEM majors.

Creating Value in Biology Courses with a Systems and EML Approach

This project is a seed grant that will focus on implementing the Entrepreneurial Mindset within an existing immunobiology course through concept maps, conceptual models, process maps, and stakeholder/feature analysis. The seed grant will test the feasibility of using these four novel activities in more STEM courses and also assess their effectiveness.

Inquiry-based Hands-on Experiments in Neuroscience

The focus of this project is to expand the opportunities available to actively engage students in hands-on learning and foster an entrepreneurial minded learning environment in a neuroscience laboratory course. This project is a seed grant to pilot the activities this fall and assess the effectiveness of the interventions being proposed in a neuroscience course and in an introductory engineering course as well.

Lessons Learned and Moving Forward

Prior to the Teaching Institute, faculty in STEM fields outside of engineering did not typically associate EML as being a viable tool worth integrating into their classroom. However, they saw significant value in using EML by the conclusion of the Teaching Institute. For many faculty in math and the sciences, entrepreneurship is a term that is often associated only with "starting a company". Through the KEEN framework and the use of the 3C's, the organizers were able to demonstrate how EML could be used in conjunction with many of the active learning techniques already employed in STEM classrooms. Additionally, while mostly anecdotal to this point, this EML content helps students to develop significant professional skills, engage in their course material, and make connections between math/science and engineering/technology. The authors plan to continue expanding upon this work to engage more faculty in EML. As the initial group of Program Transformation Grants recipients delivers their modules and collects data, the authors plan to conduct focus groups with the Program Transformation Grants recipients at the conclusion of those grants and to publish more in the future on the true impact of EML in these foundational STEM courses and its value on student learning. This will provide an opportunity to then refine how and where this EML material is delivered to maximize impact on engineering student engagement and retention.

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