Comparison of Entrepreneurial Mindset Course Learning Objectives: Evaluating Consistency and Clarity

Laine E. Rumreich, The Ohio State University

Laine Rumreich is a Master’s student studying Computer Science and Engineering at The Ohio State University. She completed her undergraduate research thesis in the Department of Engineering Education and has been a research assistant in the department for three years. Her primary research interests are in the areas of coding education and engineering entrepreneurship.

Faith Logan, The Ohio State University

Faith Logan is a current sophomore at the Ohio State University, where she is pursuing a degree in Secondary Mathematics Education. Outside of class, she is an undergraduate researcher for the Department of Engineering Education and a math tutor for the Ohio State University’s Mathematics Department.

Zachary Dix, The Ohio State University

Nicholas Rees Sattele, The Ohio State University

Nicholas is an Undergraduate Research Associate with The Ohio State Department of Engineering Education. He is in the process of completing a B.S. in Computer Science and Engineering at Ohio State. His interests include incorporating Entrepreneurial Minded Learning into engineering coursework and interdisciplinary innovation.

Dr. Krista Kecskemety, The Ohio State University

Krista Kecskemety is an Assistant Professor of Practice in the Department of Engineering Education at The Ohio State University. Krista received her B.S. in Aerospace Engineering at The Ohio State University in 2006 and received her M.S. from Ohio State in 2007. In 2012, Krista completed her Ph.D. in Aerospace Engineering at Ohio State. Her engineering education research interests include investigating first-year engineering student experiences, faculty experiences, and the connection between the two.

Dr. Ann D. Christy P.E., The Ohio State University

Ann D. Christy, PE, is a professor of Food, Agricultural, and Biological Engineering and a professor of Engineering Education at the Ohio State University (OSU). She earned both her B.S. in agricultural engineering and M.S. in biomedical engineering at OSU, and her Ph.D. in environmental engineering at Clemson University. She worked for an engineering consulting firm before entering academia and continues to collaborate with the consulting industry. She has taught courses in bioenergy, biological engineering, capstone design, HVAC, thermodynamics, waste management, professional development, and engineering teaching. Her research interests include energy, the environment, and engineering education. She is assistant dean for teaching and learning in the College of Engineering. She is a second-generation woman engineer.
Comparison of Entrepreneurial Mindset Course Learning Objectives: Evaluating Consistency and Clarity

Abstract

The entrepreneurial mindset (EM) has become of increasing interest for engineering educators as a method to better prepare students for the workforce and generate more valuable innovations. In this paper, EM is defined in terms of six principles: Curiosity, Connections, Creating Value, Communication, Collaboration, and Character. These principles, labeled as the 6 C’s, are adapted from materials from the Kern Entrepreneurial Engineering Network (KEEN). However, despite the increased adoption of EM by educators, few tools exist to aid evaluation of curricula through an EM lens and few studies investigate their effectiveness. Three EM course content evaluation tools have been created in the recent past by KEEN-affiliated universities: KEEN Student Outcomes (KSO), expanded KSO (eKSO), and Entrepreneurial Mindset Learning Objectives (EMLO). These tools have not yet been evaluated against one another to determine if they are measuring similar EM concepts. The goal of this paper is to compare and evaluate these three tools. To do so, each tool is used on three existing courses at The Ohio State University, each designed with EM in mind and each representing a different year within an undergraduate engineering curriculum. A document analysis was done for each course using each EM evaluation tool, generating nine datasets. The results for each course were then compared across the evaluation tools to measure similarities and differences between the three tools. It was found that the three tools were largely inconsistent with one another in their determination of the courses’ level of adoption of the 6 C’s of EM. Additionally, it was found that many aspects of the tools were overly abstract or particular, making them difficult to use for the purposes of measuring the EM content of a course. Although these three sets of objectives may be useful for integrating EM content in courses, the findings of this paper indicate that they are not measuring the same things and are thus difficult to utilize for the purposes of measurement.

Introduction

As employers continue to demand non-technical skills from engineering graduates, the Entrepreneurial Mindset (EM) has become of increasing concern for engineering educators. Recently, the Kern Entrepreneurial Engineering Network (KEEN), a consortium of thousands of engineering faculty [1], has been central to integrating EM into the engineering classroom. Defined around six core values, or the 6 C’s of EM, Curiosity, Connections, Creating Value, Communication, Collaboration, and Character [2], EM has been hypothesized to increase student interest in engineering [3].

The Ohio State University is in the process of incorporating EM into its engineering courses and is interested in evaluating existing curricula against the principles of EM. Unfortunately, little consensus exists on a comprehensive method for evaluating curricula through the lens of EM and little research has analyzed the effectiveness of the existing frameworks. Recently, three frameworks have emerged to accomplish the task of integrating EM content into courses, and evaluating them will be the focus of this paper. The three frameworks are the following:

1. The KEEN Student Outcomes (KSO) developed by KEEN [4].
2. The Expanded KEEN Student Outcomes (eKSO) developed by educators at a KEEN partner institution, Ohio Northern University [5].
3. Entrepreneurial Mindset Learning Objectives (EMLO) developed by educators at another KEEN partner institution, The Ohio State University [6].

Using these three objective sets, or frameworks, and through this methodology, we will begin to answer the overarching research questions for this project:

1. How consistent are the three EM frameworks, measured through the similarity of results when used to analyze EM engineering courses?
2. How clear are the three EM frameworks, measured by challenges identified when attempting to utilize ambiguous or overly-specific EM learning objectives when measuring the EM content of courses?

To answer these questions, three curricula were identified: first-year engineering laboratory coursework, a third-year technical project designed with EM in mind, and a multidisciplinary senior capstone course. These courses were chosen to span the entire career of an engineering student, from first-year to senior capstone, to give a more complete dataset. Each curriculum then underwent a qualitative document analysis using the objectives defined in each of the three EM frameworks. Results across the frameworks were then analyzed to determine the relationships and similarities between them. Both of the goals stated above: consistency and clarity, refer to how the objectives can be used to measure the EM content of courses, rather than to suggest or guide the incorporation of that content into curricula. This paper is not attempting to measure how effective these objective sets are at aiding instructors in adding EM content to courses.

The approach in this paper will provide benefit for those looking to establish a common set of EM learning objectives that can be used to measure the EM content of their courses. A clear and measurable set of objectives could make the process of integrating entrepreneurship into engineering courses more accessible and consistent for a broad audience of engineering students.

Background

Integrating entrepreneurship concepts into engineering courses has become more common in higher education in recent years [7]. A 2015 survey of ASEE members representing 100 institutions indicated that faculty and administrators strongly agree that engineering students should have access to innovation and entrepreneurship education [8]. This increased focus on embedding [9] and examining entrepreneurship in engineering coursework may also stem from engineers’ desire to design products and create customer-driven solutions [10]. In addition to this, contrary to common notions that entrepreneurs are born with the skills and mindset they need [11], research has also shown that training and education can produce entrepreneurs [12]. However, despite an interest in entrepreneurship, many students choose to pursue careers at established companies rather than creating their own start-up companies. For these students, it seems unclear as to if developing entrepreneurial skills is necessary or beneficial. The push for engineering education to develop engineers with an entrepreneurial mindset rather than pure
entrepreneurs seeks to combine the benefits of entrepreneurial thinking with this reality of job placements [13]. Engineers with this mindset, rather than focusing on starting a business venture, focus on creating personal, societal, and economic value in any job or task they encounter [1]. They are also better able to connect ideas and material and are more curious about the world around them.

The Kern Entrepreneurial Engineering Network (KEEN) has emerged as a leader in defining and distributing concepts and course content related to the Entrepreneurial Mindset (EM). KEEN is a collaborative network of colleges and professors with the shared mission of cultivating the core principles of the entrepreneurial mindset in their students [1]. This organization guides the network’s activity related to curricular development, faculty workshops, and student engagement, and have defined the 3C’s of EM to unify their model and educational materials. These values defined as the 3C’s are: Curiosity, Connections, and Creating Value. In addition to these values, there are three more core concepts to KEEN’s EM model which are: Communication, Collaboration, and Character. In this paper, we have defined these six values as the 6 C’s.

As entrepreneurially minded learning becomes more popular, more schools are joining this network and are integrating EM into their courses using frameworks and course materials established by KEEN or KEEN schools. However, due to a nationwide effort to increase evidence of student learning in higher education [14], universities are being pushed to not only integrate EM into their courses but also to measure the impact and effectiveness of the change. Unfortunately, there is no established tool for this measurement. Many schools have created their own assessment methodology or tools for this purpose. Purzer et al. [15] completed a comprehensive review of assessments related to EM and found that student surveys were the most common tool used. However, clear and measurable EM learning objectives would allow for direct assessment of EM through graded course assignments, which would be less biased than student self-reported data. This is why developing a single, clear set of EM learning objectives could reduce bias in and unify the assessments of EM.

The Three Evaluation Frameworks

Due perhaps to the large number of faculty and institutions describing and using EM, there have been challenges formalizing its implementation and defining consistent language related to its utilization. In particular, there is a lack of a consistent standard for defining specific course learning objectives related to implementing EM in courses. While KEEN provides resources and guidelines for instructors to adopt EM [1], it has been largely up to individuals to define their own specific course objectives. Many frameworks have been developed by KEEN schools to accomplish this task. Three such frameworks are the focus of this paper, but other notable frameworks exist. Arizona State [16] has developed a framework of twelve mindset and seventeen behavioral outcomes that map to the 3C’s developed by KEEN. Another framework called the KEEN-TTI framework was developed as a multi-year survey to measure student growth throughout their academic career [17]. This paper will investigate only the following three frameworks, which were chosen due to their accessibility and uniqueness when compared
to the KSO set, which was developed by KEEN and is the groundwork for most frameworks. A short description of each framework analyzed in this study follows.

**KSO**
As a method to further define the 6 C’s, KEEN developed a set of starter educational outcomes called the KEEN Student Outcomes (KSO) consisting of 18 example behaviors related to their stated student outcomes [4]. However, most of these objectives are large program goals rather than specific objectives that could be used to precisely develop or assess a course.

**eKSO**
The expanded KEEN Student Objectives (eKSO) was developed by a group of engineering faculty across the country and spearheaded by Ohio Northern University (ONU) “to more accurately reflect the ONU brand of the KEEN framework" and to allow more faculty to “feel comfortable incorporating entrepreneurial content into their courses” [5]. As an expanded framework, eKSO contains 55 objectives, unlike KSO’s 18.

**EMLO**
After reviewing the KSO framework, the faculty at The Ohio State University sought to use backward design to create a new set of learning objectives, the Entrepreneurial Mindset Learning Objectives (EMLO) that included more specific objectives and focused on integrating EM into the curriculum throughout the different stages of a student’s college career. One of the unique aspects of this approach was the definition of three efficacy levels within each of the 32 learning outcomes: Beginner, Intermediate and Advanced. With this structure, each educational outcome has both an overall definition and specific definitions for the requirements at each level [6].

**Methods**

*EM Learning Objectives Breakdown*

Three sets of objectives were analyzed in this investigation, referred to as the KSO set, the eKSO set, and the EMLO set of objectives. Each set was developed from the same 6 C’s of EM, and they were all developed for the purpose of identifying specific course outcomes to be used when designing EM curriculum. These three sets of objectives were compared by grouping the objectives based on the 6 C’s. The KSO set was already categorized into each of the 6 C’s prior to this analysis with the exception of one category, Engineering Thought and Action, that contains four objectives. These four remaining objectives were separated into one of the 6 C’s based on KEEN’s stated definitions of the values. The objectives of the eKSO were already organized into the 6 C’s. The EMLO set objectives were mostly separated into groups based on the 6 C’s but had to be further separated for this analysis. In addition, the unique separation of objectives based on Beginner, Intermediate, and Advanced in this set of objectives made a comparison to the other sets challenging. Therefore, the different proficiency levels were omitted for this analysis and the overall definition of each learning objective was used. The breakdown of how many objectives fell into each EM value for each of the three sets of objectives can be seen in Figures 1, 2, 3, and 4.
Figure 1: KSO Objective Breakdown into EM Values

Figure 2: eKSO Breakdown into EM Values

Figure 3: EMLO Breakdown into EM Values
Course Material Selection and Gathering

In order to compare EM frameworks, written or electronic course materials were used as data to analyze. The restriction of only using course materials, rather than student or instructor surveys, additional exams, or in-class evaluations, was chosen both for simplicity and repeatability. The engineering accreditation ABET follows this methodology by analyzing programs using samples of student work, syllabi, textbooks, and sample assignments, and could be considered an effective paradigm for measuring engineering coursework. For this study, the following course materials were collected and analyzed: lecture slides or videos, laboratory, project, and homework assignments, and sample student projects and assignments.

Material from three courses was used for the purposes of this analysis. These courses were used in this study for a relative rather than absolute comparison of EM content. Therefore, the courses and content within the courses chosen for this study is not of great importance to the results or goal of the paper. However, a brief description of the courses and why they were chosen follows.

The first course used in this study was a first-year engineering course that focuses on teaching first-year engineering students the foundational knowledge they will need in the remainder of their undergraduate career. Only the lab materials and design project for this course were analyzed because they had the highest potential to include EM content. This first-year course analysis was first completed by Sattele et al. [6] for the EMLO set of objectives, and this work expands on that. The second course was a third-year technical engineering thermodynamics course with a semester-long EM design project element. Only the design project assignments were analyzed because they covered most or all of the EM content in the course. The third course was a senior capstone design project course that allows students to work with outside industry sponsors to develop a solution to an engineering problem. Because this capstone project has the opportunity to include EM content throughout the course, the entirety of the semester-long project instructions and guidelines from this course were analyzed. These courses are a representation of the types of courses and skills that engineering students would experience throughout their college careers.
Data Collection

Each of the three chosen courses were analyzed using all three frameworks and a qualitative document analysis process. A team of 5 researchers, consisting of engineering undergraduate research assistants and a PhD level faculty member, each analyzed the courses independently before comparing these results, discussing them, and coming to a shared consensus. If there was not a consensus between researchers for a particular category, the plurality result was used. Further ties were broken by the Principal Investigator. The researchers examined the materials provided for each course and scored the courses using the three sets of objectives. The scores for each set of objectives was a sum of the individual objectives, and each individual objective was scored as a 1 or 0 based on if the objective was met in the course. When objectives were vague or unclear during the analysis, decisions were made based on how the researchers interpreted each objective. If the requirements for meeting an objective were very difficult or impossible to determine using only course materials, the score for that objective was rated as 0. An example of this is the objective “Be able to see the value of others.” For this objective, the researchers acknowledged that this was a possible outcome from the various course assignments, but because it was not explicitly stated in the course materials and there was not a clear method of assessing it, it was rated as 0.

After each course was scored based on each of the sets of objectives, the proportion of which objectives were met in each of the 6 C’s for each set were calculated. These values can be found in Tables 1, 2, and 3 in the Appendix. These proportions were then compared between the three sets of objectives for each of the three courses and as a single total for each set. The combined proportions can be found in Table 4 in the Appendix.

Results and Analysis

Consistency of Objectives

Figures 5, 6, and 7 show the proportions of each of the 6 C’s categories that were met for each course studied, grouped by each of the three sets of objectives.

![Proportion of the 6 C's in A First-Year Engineering Course](image)

**Figure 5:** Proportion of EM Values for First-Year Engineering Course
It is apparent in the above bar graphs that the three sets of objectives measured the EM level of each course very differently. There was no clear pattern in the measurements, as visible by the variation in the above bar graphs. No single set scored consistently higher or lower in any of the EM values across the three courses. An example of the variability of the sets is the Character evaluation using the KSO set of objectives across the three courses. In one course, the KSO set rated Character the lowest, but in another it was tied for the highest proportion of objectives met. This trend is exhibited across all three of the courses that were analyzed, with the scores varying widely for each value in each course. Although there were similarities between the sets at times, such as objectives like “meet commitments” appearing in 2 of the 3 sets, the sets were generally very different from one another. However, due to the fact that each set was created from and grouped by the 6 C’s of EM, there should be some similarity in how courses are rated based on
the sets of objectives. Despite this, many categories in the above graphs differ by 50 percent between the three sets of objectives. Based on this result, the sets of objectives do not appear to be measuring the same things.

It should be noted that a more robust statistical analysis of this dataset could not be completed effectively due to the small sample sizes in each category of results. This characteristic, as well as the qualitative nature of the data collected, lends itself to a visual comparison of the data instead.

Clarity of Objectives

During the qualitative document analysis process, a number of issues related to the clarity of the EM objectives were discovered. The KSO set had 18 objectives which varied in specificity. Three of the 8 objectives in this set were found to be extremely vague and thus difficult to measure in any concrete way in the course assignments as written. The eKSO set had 55 objectives, and at least seven of them led to confusion in the analysis process due to their wording and lack of specificity. The EMLO set had 32 objectives, many of which were overly specific or difficult to understand. This resulted in courses that did not meet objectives because they were not using the formula, tool, or teaching method specified in that set of objectives. For example, Objective 7 in the EMLO set states specifically that twenty or more sketches of brainstormed ideas must be created in order to meet the objective, which is unlikely to be met unless a course is specifically trying to meet that requirement. Each of the measured sets had objectives that were problematic due to vagueness, too much specificity, or confusing word choice. The vagueness of these objectives is one explanation for why each set of objectives can vary so greatly when compared to the others.

Another difficulty during this analysis process was the lack of measurability of many objectives. For instance, Objective 9 in the eKSO set states that students must “take ownership of, and express interest in topic/expertise/project.” Through the methodology used in this analysis, the researchers could not determine that students were taking ownership of or an interest in the course projects. This objective would be difficult to definitively score in any course and is particularly difficult given only course assignments to assess. Another objective that was challenging to measure was Objective 50 from the eKSO set, which states that students must “meet commitments.” The researchers found it hard to imagine a course in which students would not meet commitments, as due dates, class attendance, and assessments are commitments that students must meet in order to succeed in any course. In this case, it was difficult to determine the level of meeting commitments students were expected to achieve in a course, which made it difficult to measure the objective. Another example of this same issue is from the EMLO set of objectives, which is to “listen to others to advance ideas and gather input.” One final example of a lack of clarity and measurability in an objective is from the KSO set, which states that students must “demonstrate constant curiosity.” The word choice in this objective is unhelpful as researchers and faculty cannot determine if students are constantly curious, and thus cannot use this objective to measure the effective integration of EM in their course.
Conclusions

Consistency of Objectives

A comparison of three sets of EM learning objectives, analyzed using an evaluation of EM content in various engineering courses, revealed little similarity between the sets of objectives. This lack of consistency is despite the use of the same major themes and theme definitions in the development of each of the sets of objectives. This lack of consistency in the three sets of objectives reveals not only a lack of similarity between the objectives, but also a lack of similarity in what the objectives are measuring. This means that as different KEEN partner schools develop individual objectives for their courses, they measure the effectiveness of EM in their courses very differently, and a course that would be considered very high in EM at one institution could be rated much lower at another. This lack of consistency makes integrating EM into courses more difficult and makes comparisons of EM courses at different universities more problematic. Although some differences in goals are expected based on the priorities of various institutions, the striking lack of similarity between the three sets of objectives measured in this study reveals a more systematic lack of consistency related to measurement of the 6 C’s of EM.

Clarity of Objectives

The ambiguity of many of the objectives from each analyzed set was identified during the analysis process for this study. Some of this lack of clarity resulted from the fact that many of the objectives were deemed too difficult to objectively measure in a course, such as to “demonstrate constant curiosity about our changing world.” The solution to this current lack of clarity is to improve specificity and measurability in EM objectives. Measurable course outcomes often involve observable criteria, time frames, and numerical goals. For example, rather than “Students will develop and demonstrate proficiency in writing and verbal skills,” an effective objective might be "Present an original business plan at a design showcase."

Many other objectives, although possible to measure, are very difficult to measure using only syllabi and coursework, such as the objective to “develop an appreciation of hard work and recognize the benefits of focused and fervent effort.” Surveys of student perceptions could be used to measure this objective, but this is not measurable through course descriptions and would be challenging to integrate into many courses. This lack of written documentation on whether a course objective is met makes the process of measuring the integration of EM material in a course very challenging. To address this issue and make objectives more measurable, only objectives that can be described in course descriptions, assignments, or textbooks should be utilized. As mentioned in the methodology section of this paper, the engineering accreditation process that ABET follows uses a methodology of analyzing programs using samples of student work, syllabi, textbooks, and sample assignments, and might be considered a more effective paradigm for measuring engineering coursework.
Recommendations

The stated goal by KEEN of EM outcomes is to create and assess entrepreneurial mindset in students [1]. Toward this end, new objectives should be specific and measurable based on only samples of student work, syllabi, and course assignments. With learning objectives that meet these specifications, curriculum designers could not only integrate EM into courses in a more straightforward way, but also measure the impact of the EM coursework on students.

Another study by Brunhaver et al. [19] produced similar findings about the difficulty of assessing EM content in courses using the existing KSOs. The solution to this problem of measurability proposed in that study was to develop an assessment of self-reported student understanding of EM. The recommendation from this present study is to instead modify or redefine the objectives used to integrate EM content into curriculum to be measurable, rather than measuring it using a separate assessment tool.

Although the sets of objectives analyzed in this study were difficult to use for the purposes of measuring the EM content of courses, they can be used in other ways, including to help guide the process of generating EM course objectives. These objectives can also be useful for the purposes of integrating EM content into courses, but are not necessarily as effective for assessing student achievement of those EM learning outcomes.

Limitations and Future Work

Limitations

One of the primary limitations of this study is the small amount of data collected, which makes robust statistical comparisons of the frameworks ineffective. Another limitation is with the qualitative nature of the research methodology used when analyzing the EM content in courses. Qualitative decisions were based on how well course documents matched with objectives in the frameworks, and this could lead to bias in the data. One final limitation with this study is that there were a number of objectives that could not be measured using the chosen methodology. However, this study was meant to determine whether this exact problem would occur when utilizing these objectives. Thus, this lack of measurability is one of the results of the study.

Future Work

To broaden the scope of this study, an analysis of other existing sets of EM objectives could be completed as well as increasing the number of courses included in the study. With more data, a statistical analysis may become possible. In addition, a study of student and faculty perceptions of the value of various existing EM objectives could be completed. This would not only help researchers better understand the motivation behind integrating EM in a classroom, but also help narrow the list of EM objectives based on those that are most important to various stakeholders. Defining important EM concepts and developing a consistent and clear set of course objectives is critical to convincing more institutions and faculty to adopt EM curriculum.
References


## Appendix

**Tables**

**Table 1: First-Year Engineering Course Proportion of EM Values**

<table>
<thead>
<tr>
<th></th>
<th>Curiosity</th>
<th>Connections</th>
<th>Creating Value</th>
<th>Communication</th>
<th>Collaboration</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSO</td>
<td>0.667</td>
<td>0.333</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>eKSO</td>
<td>0.500</td>
<td>0.333</td>
<td>0.333</td>
<td>0.714</td>
<td>0.375</td>
<td>0.500</td>
</tr>
<tr>
<td>EMLO</td>
<td>0.250</td>
<td>0.750</td>
<td>0.600</td>
<td>1.000</td>
<td>0.667</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Table 2: Third-Year Technical Course Proportion of EM Values**

<table>
<thead>
<tr>
<th></th>
<th>Curiosity</th>
<th>Connections</th>
<th>Creating Value</th>
<th>Communication</th>
<th>Collaboration</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSO</td>
<td>0.667</td>
<td>1.000</td>
<td>0.500</td>
<td>0.500</td>
<td>1.000</td>
<td>0.500</td>
</tr>
<tr>
<td>eKSO</td>
<td>0.700</td>
<td>0.556</td>
<td>0.556</td>
<td>0.857</td>
<td>0.375</td>
<td>0.333</td>
</tr>
<tr>
<td>EMLO</td>
<td>0.500</td>
<td>0.375</td>
<td>0.700</td>
<td>1.000</td>
<td>1.000</td>
<td>0.667</td>
</tr>
</tbody>
</table>

**Table 3: Senior Year Capstone Design Project Course Proportion of EM Values**

<table>
<thead>
<tr>
<th></th>
<th>Curiosity</th>
<th>Connections</th>
<th>Creating Value</th>
<th>Communication</th>
<th>Collaboration</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSO</td>
<td>0.667</td>
<td>1.000</td>
<td>0.750</td>
<td>0.500</td>
<td>1.000</td>
<td>0.250</td>
</tr>
<tr>
<td>eKSO</td>
<td>0.700</td>
<td>0.444</td>
<td>0.556</td>
<td>1.000</td>
<td>0.500</td>
<td>0.833</td>
</tr>
<tr>
<td>EMLO</td>
<td>0.500</td>
<td>0.750</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>0.667</td>
</tr>
</tbody>
</table>

**Table 4: Combined Proportions of EM Values Across Three Courses**

<table>
<thead>
<tr>
<th></th>
<th>Curiosity</th>
<th>Connections</th>
<th>Creating Value</th>
<th>Communication</th>
<th>Collaboration</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSO</td>
<td>0.417</td>
<td>0.625</td>
<td>0.767</td>
<td>1.000</td>
<td>0.889</td>
<td>0.444</td>
</tr>
<tr>
<td>eKSO</td>
<td>0.633</td>
<td>0.444</td>
<td>0.481</td>
<td>0.857</td>
<td>0.417</td>
<td>0.556</td>
</tr>
<tr>
<td>EMLO</td>
<td>0.667</td>
<td>0.778</td>
<td>0.583</td>
<td>0.500</td>
<td>0.833</td>
<td>0.417</td>
</tr>
</tbody>
</table>
# KSO Objectives

## Curiosity
1. Demonstrate constant curiosity about our changing world.
2. Explore a contrarian view of accepted solutions.
3. Apply creative thinking to ambiguous problems.

## Creating Value
1. Identify unexpected opportunities to create extraordinary value.
2. Persist through and learn from failure.
3. Evaluate technical feasibility and economic drivers.
4. Examine societal and individual needs.

## Connections
1. Integrate information from many sources to gain insight.
2. Assess and manage risk.
3. Apply systems thinking to complex problems.

## Communications
1. Convey engineering solutions in economic terms.
2. Substantiate claims with data and facts.

## Collaboration
1. Form and work in teams.
2. Understand the motivations and perspectives of others.

## Character
1. Identify personal passions and a plan for professional development.
2. Fulfill commitments in a timely manner.
3. Discern and pursue ethical practices.
4. Contribute to society as an active citizen.
**eKSO Objectives**

**Curiosity**
1. Develop a propensity to ask more questions.
2. Be able to formulate salient questions.
3. Question information that is given without sufficient justification.
4. Recognize and explore knowledge gaps.
5. Critically observe surroundings to recognize opportunity.
6. Be able to self-reflect and evaluate preconceived ideas, thoughts, and accepted solutions.
7. Explore multiple solution paths.
8. Gather data to support and refute ideas.
9. Take ownership of, and express interest in topic/expertise/project.
10. Observe trends about the changing world with a future-focused orientation/perspective.

**Creating Value**
1. Identify the needs and motivations of various stakeholders.
2. Express empathy in identifying problems and exploring solutions.
3. Create solutions that meet customer needs.
4. Define a market and market opportunities.
5. Craft a compelling value proposition tailored to specific stakeholders.
6. Modify an idea/product based on feedback.
7. Focus on understanding the value proposition of discovery.
8. Describe how a discovery could be scaled and/or sustained, using elements such as revenue streams, key partners, costs, and key resources.
9. Engage in actions with the understanding that they have the potential to lead to both gains and losses.

**Connections**
1. Understand ramifications (technical and non-technical) of design decisions.
2. Identify and evaluate sources of information.
3. Connect life experiences with class content.
4. Connect content from multiple courses to solve a problem.
5. Collect feedback and data from many customers and customer segments.
6. Integrate/synthesize different kinds of knowledge.
7. Consider a problem from multiple viewpoints.
8. Understand how elements of an ecosystem are connected.
9. Integrate non-monetary and monetary factors into a triple bottom line assessment.

**Communications**
1. Articulate ideas to diverse audiences.
2. Present technical information effectively (graphs, tables, equations).
3. Identify and organize information in a format suited to the audience.
4. Provide and accept constructive criticism, including self-evaluation.
5. Produce effective written reports.
6. Produce effective verbal presentations.
7. Manage informal communications (meetings, networking, etc.).

**Collaboration**
1. Recognize their own strengths, skills, and weaknesses, as well as those of others.
2. Develop a professional network.
3. Suspend initial judgement on new ideas.
4. Identify and work with individuals with complementary skill sets, expertise, etc.
5. Be able to lead, delegate, and follow.
6. Be aware of and able to work through interpersonal conflict.
   Be able to teach and learn from peers.
7. Be able to network and see the value in others.

**Character**
1. Demonstrate an ability to set, evaluate, and achieve personal and professional goals.
2. Meet commitments.
3. Recognize and evaluate potential impacts while making informed ethical and professional decisions.
4. Accept responsibility for their own actions and credit the actions of others.
5. Develop an appreciation of hard work and recognize the benefits of focused and fervent effort.
6. Work toward the betterment of society.
EMLO Objectives

Curiosity
1. Identify Opportunity: Define and create ideas for new products or services that fit within the business strategy and that provide a potential economic or social value to a group of users willing to purchase this product or service.
2. Investigate Market: Through a series of primary (talking with potential end users) and secondary (reading) research, identify potential end users and create graphical user profiles (personas) to define typical user profiles in a way to create empathy.
3. Identify Supply Chains and Distribution Models
4. Protect Intellectual Property

Creating Value
1. Define Problem: Based upon the identified opportunity and primary and secondary research, create a formal definition of a specific problem to solve that creates value by identifying a specific task and associated pain and gains.
2. Create Preliminary Business Model: Using the nine-point Business Model Canvas (BMC) format and create a draft business model.
3. Develop Concepts & Models: Throughout the conceptual design phase, continue to test ideas with user feedback using all types of communication tools including sketches, mockups, models, and test runs.
4. Analyze Solutions: By using a variety of tools, and through a series of iterations, down-select the array of concepts to select a final concept that best meets the weighted user and institutional needs.
5. Determine Design Requirements: Based upon the final product concept, create design requirements to form the foundation for detailed design. Rank order the set of requirements to provide a basis for design tradeoffs.
6. Perform Detail Design: Driven by the weighted set of design requirements, perform detailed design, taking into account usability and human interface issues.
7. Develop New Technologies
8. Create Model/Prototype: Based upon design details, build actual models to best represent the functional, visual, and human interface aspects of the solution.
9. Verify Functions: As an iterative process throughout the design, identify (and implement) tests to verify the product meets the technical requirements making tradeoffs when necessary based upon their weighted value of importance.
10. Develop Partnerships and Build a Team: Characterize the partners to provide all the resources needed to produce a viable solution.

Connections
1. Define user needs.
2. Evaluate Technical Feasibility: As a result of the conceptual design effort, evaluate technical feasibility and economic and societal value and add institutional needs to the weighted user needs (e.g., time to market, technical risk, financial risk, etc.).
3. Assess Policies & Regulations: By studying market requirements and user needs, identify all policy, standards, and regulatory issues that are constraints that must be met (e.g., FDA, UL, and CE approval).
4. Validate Market: The iterative process of validating the market throughout the project should finalize with a series of activities that demonstrates how the final product meets the user needs making tradeoffs when appropriate based on weighed value of importance.
5. Validate user needs.
7. Evaluate societal benefits.
8. Demonstrate creativity by making connections between different domains of knowledge.

Character
1. Act ethically based on evaluation of the social and environmental impacts of one’s decisions and professional endeavors.
2. Empathize with different individual/group perspectives, feelings, and needs.
3. Implement a professional development plan based on self-reflection of one’s goals and values.