Work in Progress: Gap Analysis for Assessment of Entrepreneurial Mindset in Engineering

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Gap Analysis for Assessment of Entrepreneurial Mindset in Engineering

Abstract

The efforts to incorporate an Entrepreneurial Mindset (EM) in engineering have grown significantly in recent years. The purpose of this work-in-progress research is to determine what tools and methods are currently used to assess EM, and what gaps exist in the current practice. To determine the current practices we performed a comprehensive literature review, an assessment review of cards on Engineering Unleashed, and a series of faculty interviews. To determine the gaps in the current assessment tools, we reviewed the results from each of the data sets and conducted additional industry interviews. Our team has now reviewed more than 2,000 unique data assets for possible inclusion in an assessment database. Around 300 of the reviewed tools represent EM assessment tools that could be adapted for use by other researchers.

Our preliminary findings indicate that most faculty and programs are currently using student surveys to assess EM. Most methods in practice are indirect, with a few exceptions like EM concept mapping. We have developed a database of methods for review by faculty to determine tools that may be helpful for them in practice. The largest gaps we identified included faculty-focused assessment tools and direct measures for students. Our future work includes development of new assessment tools to address these gaps in part.

Introduction

The engineering education community continues to increase efforts to help students build an entrepreneurial mindset. For this work, we define entrepreneurial mindset to be consistent with the Engineering Unleashed (EU) community, "*An entrepreneurial mindset (EM) influences the way you think about the world and act upon what you see. It is a collection of mental habits that empower you to question, adapt, and make positive change, leading you to: Recognize and identify opportunities; Focus on their impact; Create value in any context.*" [1]

The increase in efforts to implement EM in engineering classrooms has been driven in part by the formation of the growing Engineering Unleashed community. The community is available online at no cost with resources on engineering education, EM, and related topics. The community members upload class materials, ideas, and stories to informal collections referred to as cards. The umbrella organization of partner institutions is the Kern Entrepreneurial Engineering Network (KEEN); partners include more than 50 colleges and universities across the United States.

One challenge many engineering educators face when developing EM modules in classrooms is how they might assess student mindset shifts. The Engineering Unleashed community has worked on this topic for many years, and many useful tools have been developed or adapted from the fields of education or psychology. This paper describes a long-term effort to categorize and understand the types of assessment strategies that may work well to understand entrepreneurial mindset (EM) in engineering students.

Our team is also working to help those new to the topic to find tools quickly that may align with the EM project or research questions they are working on. The research group includes experts in assessment from the fields of education, psychology, and engineering - a composition that allows us to evaluate different tools from the perspective of validity and the educator. While we cannot yet answer each research question below, this paper presents our current work-in-progress on several research questions:

1. What tools and best practices have been developed for the assessment of EM?
2. What are the best descriptors of assessment for discovering gaps in EM assessment tools?
3. How might we connect people to EM assessment tools that already exist?

Background

Engineering faculty have been working to incorporate entrepreneurial mindset in curriculum for many years. Several efforts have been made by prior authors to summarize the existing literature on assessment of EM. In an effort to find the appropriate tools for assessing entrepreneurial mindset, a systematic literature search resulted in a comprehensive listing of available instruments and surveys. Prior work by Grzybowski et al. had provided a preliminary structure category [2]. Each individual instrument or survey has multiple items listed including what is being assessed, any studies used to determine its reliability and validity, and references.

What makes our project unique is the extension of our searching beyond the archival literature and the development of a taxonomy to categorize the existing assessment tools. We have reviewed informal publications (cards) on the Engineering Unleashed website (engineeringunleashed.com), which faculty use to share EM modules and early results from their work. Additionally, we have interviewed academic institutions in the Engineering Unleashed community and asked them to submit assessment tools for review and characterization. We have added this to a fresh review of the literature, and the combination of all these data sources is a more comprehensive review of tools available.

***Table 1**. Summary of prior assessment summaries of entrepreneurial mindset literature.*

Author	Year	Organization	Data Sources	Methods
Grzybowski et. al. [2]	2020	List of EM assessment instruments	Literature, EU cards	Systematic literature search
Morgan and LeDoux [3]	-	List of EM assessment articles	Literature	Authors listed the prior works on EM assessment
This Study	**2023**	**Taxonomy**	**Literature, EU cards, EU schools**	**Generated a taxonomy for organizing EM assessment tools**

The second unique contribution of our work is the structure we have developed for organizing the types of assessment tools we found. We refer to this organizational structure as a taxonomy, and discuss the development of the taxonomy in detail in this paper. The taxonomy is a categorization methodology for assessment tools that we have used to begin filtering the assessment options for EM.

Methods

Data Collection and Literature Search

For this project we reviewed and collected data from three primary sources. The peer reviewed literature including conference papers and journal articles, the Engineering Unleashed campus representatives, and the Engineering Unleashed card repository. An overview of the process is shown in Figure 1.

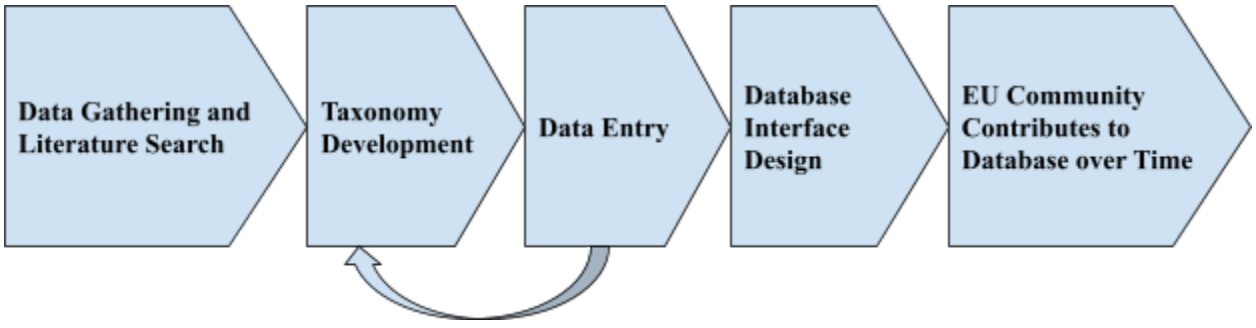

Figure 1. An overview of the process design for creating, refining, and utilizing this taxonomy of assessments.

Literature Review

We used traditional search engines and tools to review the published literature on assessment tools for entrepreneurial mindset. Because the topic spans fields of business, entrepreneurship, engineering education, and psychology our initial search yielded a high number of articles and papers (176 papers) for further review.

A team of faculty members and post doctoral students all supported the search effort and collaborated using a shared public Zotero repository. After our first round of data collection in Zotero, we conducted a more detailed review to determine if the material or tool was reasonable for adaptation for engineering and/or entrepreneurial mindset. We classified the research papers using the taxonomy developed by our team for application in engineering education.

No specific date ranges were specified for the search of the archival literature, however most papers on the topic of EM in engineering are relatively recent. Our search found less than 5 papers on the topic prior to the year 2000. Each of the members of the research team used different search engines for the literature search, and duplicate entries were then removed when they occurred.

Engineering Unleashed Campus Interviews

KEEN's Engineering Unleashed platform provides resources for learning support, instructional design, and assessment. However, faculty and staff still find assessment challenging for both content and measuring the 3C's (Curiosity, Creating Connections, and Creating Value). To learn more, we facilitated 30-minute interviews with faculty and staff in the Network who directly work with the assessment of entrepreneurial minded learning. To identify participants, we asked KEEN to include a question in their annual survey to member institutions identifying assessment leaders. KEEN provided a list of contacts to the research team as potential participants. The research team then contacted each participant to ask if they were willing to be interviewed as part of our project. A member of the research group managed the correspondence, scheduling, and interviewing.

To more deeply understand how members of the Engineering Unleashed network incorporated and assessed EM on their campuses, interviews were then conducted with 44 participants from 28 Engineering Unleashed member institutions. Participants were asked about the integration of EM into the curriculum at their institutions, the approaches they use to teach EM in coursework, and the methods they use to assess students' learning of EM. The interviews also inquired into participants' experiences with the assessment tools currently available through the Engineering Unleashed network and what additional assessment needs they feel remain unmet. Interview transcripts were analyzed inductively, with emergent themes identified and coded through iterative review.

In addition to uncovering how EM is taught at Engineering Unleashed member institutions and identifying assessment needs, these interviews resulted in participants sharing over 70 locally-developed assessment tools for inclusion in the database. A number of these instruments were unpublished, creating an opportunity for interview participants to share their work with peer institutions in the Engineering Unleashed network.

Engineering Unleashed Card Database

As part of identifying, mapping, and organizing established EM assessment tools and resources into a vetted framework, we also reviewed every card on the Engineering Unleashed site, a total of 1,781 cards (as of July, 2021).

To do this, we used an explicit coding mechanism detailed here. While individual card errors or inconsistencies may be found, in general this is a fairly accurate description of the state of EM assessment in the cards. We first opened every card and reviewed it at a high level, focusing primarily on the materials that were uploaded. Every document labeled "Assessment/Rubric" was downloaded and examined. They were then coded as "Assessment of Content" or "Assessment of EM", and if coded as Assessment of EM more labels were added (Rubric, Survey, etc.). Other documents, such as those labeled "Activity" that had "Assessment" or "Rubric" in the file name were also examined. In general, however, if it was not explicitly stated in the card, it was generally not coded as "assessment." There were examples where it is clear that cards are works in progress and may eventually include assessment, however we coded it as the card stood at this time point (Fall, 2021). Some users also categorized items as "assessment/rubric", but upon further inspection it appeared to be the instructions for completing the project. Since most of these cases did not include the mechanism for assessing the project, in these situations it was coded as not including assessment (content or for EM).

This coding mechanism means it is possible many more cards assessed EM; however, it needed to be 1) addressed explicitly by using the "Assessment/Rubric" tag on the KEEN card (i.e., it's possible it was uploaded as part of a different document not loaded as such and therefore was not downloaded), and 2) addressed explicitly the 3C's or EM by labeling it as such (i.e., it is possible rubrics addressed EM objectives that were identified in the objectives section; however, if they were not identified as such on the rubric they were not coded as EM or the 3C's). Similarly, when it came to identifying content assessments, they had to be labeled as "Assessment/Rubric"; if they were labeled as "Activity", for example, they were not examined. Many assessments may have been included in ASEE papers uploaded to KEEN cards, however these would be revealed through the literature search and were therefore not examined as part of this analysis component technique. Finally, there are many cards that are talks, professional development workshops, KEEN conference presentations, ASEE updates, etc. for which having an assessment would not be relevant, therefore the percentages reported below must be interpreted cautiously.

Taxonomy and Tool Design

Developing the taxonomy and tagging the assessment tools was conducted through a four-stage coding process (Figure 2). In Stage 1, the team used the data from the interviews, cards, literature search, and focus group to begin a preliminary taxonomy of "tags" that might help faculty navigate assessment tools. In Stage 2, using this taxonomy, the research team coded a sample of assessment tools deductively with these tags, first coding each item by common assessment terms (e.g., formative/summarize and direct/indirect) as well as terms that we anticipated would be of interest to users such as class size (e.g., small/large) or level of expertise required. The team used a broad approach in the initial application of tags in the first brainstorm stage along with how we defined the tags. The research team met regularly to share their perspectives on the coding process and reach consensus on how tags should be applied.

In Stage 3, following this initial coding, we sought feedback from an assessment advisory group made up of both engineering content and measurement experts. That group helped identify additional tags as well as eliminate redundant ones, resulting in a revised taxonomy. In Stage 4, the research team used the revised taxonomy to begin logging assessments: looking at an assessment and determining which classifications it met in the taxonomy. In this stage, the taxonomy was further revised to reduce the number of factors by combining taxonomy tagging categories that were similar and eliminating categories that were not consistently used across the assessment tools.

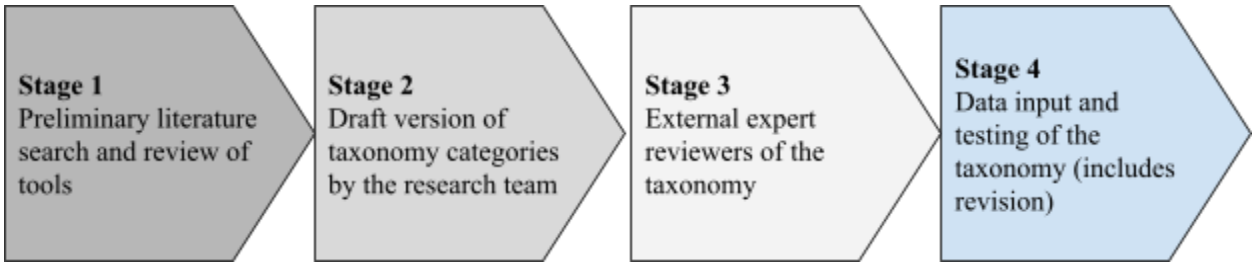

Figure 2. Steps used for the development of the taxonomy.

Database and User Interface Tool Design

The last stage of the project included the development of a final form of the database, an intake form, and a user interface for navigation of the database. The intake form requires users to add new data in alignment with this taxonomy. These entries can also link to additional resources such as instructor resources or manuscripts. The data is collected using Google tools and stores a summary of the intake form in a Google Sheet.

To enable users to explore this collection of assessment tools and reports we designed a simple web interface using React to assist in narrowing the selection of entries based on the categories in the taxonomy. The design encourages exploration based on the most discriminative categories

so that the results are more manageable in quantity and most relevant to the user's needs. We created a decision tree to narrow the results rather than allowing for arbitrary filtering of the data. This reduces the cognitive load in searching by focusing the user on the more powerful filters first so that the list of matching resources is most relevant to the user's needs. The table of results includes links to the posted tool and related resources, if available, such as the journal article or conference paper. The prototype user interface is illustrated in Figure 3, where it is possible to see some of the taxonomy ratings related to adoption of the resource such as ease of implementation or type of instrument.

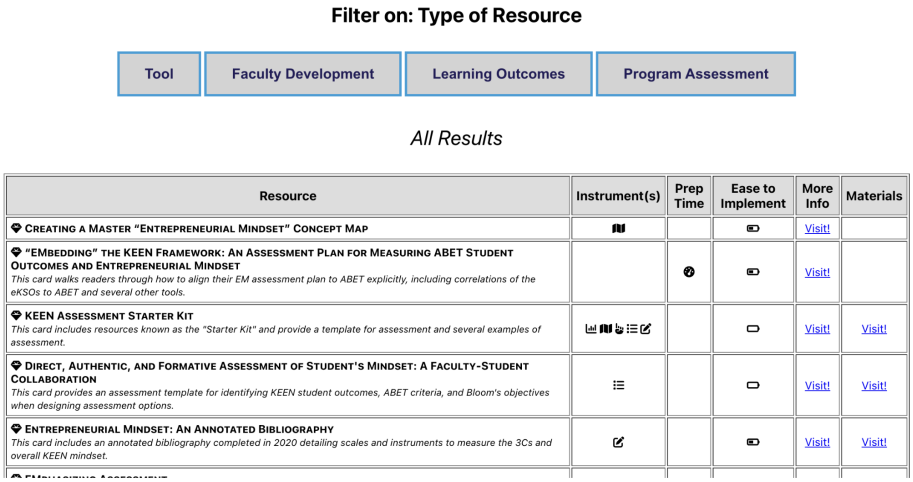

Figure 3. Example of the type of filtered data in the database.

Results

The final taxonomy used for the intake form and the website is given in Table 2. The taxonomy represents the final organizational structure of assessment tools for EM that we developed and the structure is reflected in the web-based tool currently under development.

Table 2*. Taxonomy for the organization of assessment tools for EM.*

Taxonomy Category	Options	Description
Scale	Classroom, Program	Classroom is focused on one class, module, or unit. Program would be focused on groups of classes, groups of faculty, or larger units like college level EM initiatives.
Purpose	Formative, Summative	Formative (used FOR learning typically during the process) Summative (used OF learning typically at the end of the process)

EM Focus	Qualitative, Quantitative, Mixed	Quantitative methods rely on numerical data and statistical procedures for data analysis. Qualitative methods rely on descriptive narrative for data analysis. Mixed methods employ the use of both numerical and descriptive narratives for analysis.
Instrument Type	Artifacts, Concept Inventory, Concept Map, Interview, Observations, Peer-Assessment, Reflection, Rubric, Self-Assessment, Survey, Test/Exam	There are a variety of assessment formats that can be used to evaluate student learning ranging from self-assessment to peer assessment, rubrics, concept maps, reflections, etc.
Exemplar	Yes	This tag is for tracking examples, tools, methods that are well executed and clear for another person to implement.
Validity Evidence	None, Validity Evidence Exists	Every instrument is subject to validity examination. Building the case for an instrument being valid is ongoing and dependent on the use, context, population, etc. In this work we are identifying instruments that have provided information about the validity of the instrument either through peer-reviewed publication OR some effort by the research team to validate.
Target	Students, Faculty/Staff, Alumni, Industry, Other	Each instrument has a target participant group
Size	Small [<60], Large [>=60],	The size of group or class that would be best served with this type of assessment.
Preparation Time	Low, High	The time required to adapt this assessment tool or method to a new classroom or context. Low would be less than 2 hours.
Data Complexity	Low, High	The complexity of the type of assessment data that is generated using this assessment tool or method. A low complexity data set might be simple multiple choice survey questions. A high complexity example might include several connected factors in a survey.

Expertise	Low Expertise, Moderate Expertise, Assessment Expert	An estimate of the type of experience level of the person implementing this tool that might be needed.
Level of Analysis	Student, Class, Program	For analysis purposes, the data is evaluated and/or reported either at the student/individual level, the class or a group aggregate level, or for a program or multiple groups level.
Outcome Type	Trend, Snapshot	Indicates the type of outcome best-suited for the instrument
Change or Improvement over Time	Individual, Program	Assessment is suitable for examining changes over time either by individual, program, or both.
Timing	One-Time / Mastery, Pre-Post, Trend Data	Timing indicates how frequently the assessment can be administered to the same individuals or groups of individuals. One-time indicates that the instrument is best-suited once. Pre-post indicates the assessment should be administered at the start of a course, intervention, program, etc. and once more at the end. A measure that can be used for trend data may be administered several times in a term or several years in a program. If only assessed once it can indicate baseline knowledge, skills or beliefs OR at the end of a class or program culminating knowledge, skills, or beliefs (i.e., mastery). Pre-post and trend data can help track growth or change over time.
ABET-Related	Not Aligned to ABET, Aligned to ABET	Indicates whether the assessment is aligned to ABET or not, and if so, to which of the 7 standards.
Student Learning Outcome Related	No, Yes	Indicates the type of outcome is tied to a student learning outcome in a course.

The final result is a database of more than 300 tools and materials that have been reviewed and categorized for assessment of aspects of entrepreneurial mindset. The review and classification of data is still in progress, but we feel our preliminary findings are substantive based on the number of materials we have reviewed and organized. A summary of our categorized work to date is given in Table 3.

We understand for the engineering education community that tools that have emerged as highly valuable are important to highlight. While our work continues, the tools and techniques in Table 4 are a few of the best practices for assessment of EM we found in our early reviews, and we recommend them.

Table 3. *Summary of the final data set of tools that may be helpful for assessment of EM.*

Data Source	Original Dataset Size	Final entries in categorized database
Literature Search	176 conference and journal papers	In progress
Cards on EngineeringUnleashed	1,781 cards published on the Engineering Unleashed website	217 (12%) assessed EM in some way
Campus interviews	29 interviews with 28 institutions and 42 participants	72+ artifacts and tools
Total	~2,000	300+ and growing

Work-in-Progress Conclusions

A new project was developed by an interdisciplinary team of experts in psychology, education, and engineering to map existing assessment tools for entrepreneurial mindset. We have focused on several research questions as outlined in the introduction.

Research Question 1: What tools and best practices have been developed for the assessment of EM?

We have gathered lists of possible assessment tools and examples from a variety of sources, including the Engineering Unleashed database of cards, which gave us an initial dataset of more than 2,000 artifacts. We are still reviewing the data, but have identified and organized around 300 assessment methods that have relevance for EM.

Research Question 2: What are the best descriptors of assessment for discovering gaps in EM assessment tools?

We have developed and vetted a taxonomy for organizing the large number of tools available. Our taxonomy is shown in Table 2 and we welcome comments from the engineering education community about the descriptors selected. We are in the process of using this taxonomy to code and identify gaps in EM assessment tools.

Research Question 3: How might we connect people to EM assessment tools that already exist?

We are in the early stages of building a searchable online database that will allow engineering educators to search for tools that may be helpful for their applications. A preliminary version is shown in Figure 3. As we finish reviewing our initial data set, we will continue to build this tool and test it with the Engineering Unleashed community.

Table 4. *Examples of useful assessment tools for EM with taxonomy categories that we found in our preliminary organization of data.*

Taxonomy Tag	Concept Maps	Mapping EM Indicators / Learning Objectives to Rubrics	Student Surveys - Items Mapped to EM Indicators	VALUE Rubrics	5-Dimensional Curiosity Scale	Situational Motivation Scale (SIMS)
Short Description	Assessing through students' visual representations of EM	Assessing through rubrics with line items linked to EM indicators	Assessing through survey items directly linked to EM indicators	Assessing through crosswalking the 3C's onto the AAC&U VALUE rubrics.	Assessing curiosity through a validated survey tool with five subscales.	Assessing curiosity through a validated survey tool measuring student interest and self-regulation on a specific task.
URL/ Citation	[4]	[5]	Many Examples [6]–[8]	[9] and [10]	[11] and [12]	[13] and [14]
EM Focus	EM	3C's	3C's	3C's	Curiosity	Curiosity
Type of Assessment	Direct	Direct	Indirect	Direct	Indirect	Indirect
Scale	Class	Class, but could be used Programmatically	Class, but has been used Programmatically	Class or Program	Class or Program	Class
Prep Time	Low	Low	Low	Low	Low	Low
Complexity	Moderate	Low	Moderate	Low	Moderate	Moderate
Size	All	All	All	All	All	All
Data Type	Qualitative	Quantitative	Mixed Methods	Quantitative	Quantitative	Quantitative

Note. EM Focus of 3C's indicates the measure could be used to measure each of the 3C's individually depending on the EM indicators chosen, while EM indicates EM is measured more holistically.

Future work will include the development of a set of training materials that will allow users to navigate through the database using the taxonomy developed by our research team. The training materials will connect directly to the database interface, allowing users to search for tools that might best suit their application or needs for assessment.

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