

Preliminary Efforts to Define, Assess, and Improve Students' Ability to Make "Connections" as Part of Developing an Entrepreneurial Mindset

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Abstract— Work in progress (research-to-practice). The entrepreneurial mindset, as articulated by the Kern Entrepreneurial Engineering Network or KEEN, rests on a foundation of three “C”s - *Curiosity*, *Connections*, and *Creating value*. In prior work, we developed an approach to assess students’ situational curiosity in response to class activities. We discovered that the creation of real artifacts excited student curiosity and explored the extent to which open-ended problem solving did as well. We have also proposed rubric-based assessments of student designs as a measure of value-creation. The second of the three “C”s, connections, has presented assessment challenges to this point.

In this work, we discuss our literature review and search for valid and reliable instruments and subscales for connections. We propose a “2I” model where connections is defined as the ability to “integrate” knowledge to provide “insights”. We also propose an in-class activity similar to a brainstorming exercise already in use in many design-based courses. We have developed a rubric for assessing results of this exercise that can be used to both assess participants’ facility with forming connections and as the basis for a conversation with students about how to make more meaningful connections. Further, faculty can use this activity to stimulate students’ idea generation about course topics. We have tested this approach in two settings, and find initial results promising. We continue to seek feedback from the community as we work to turn this into a valid and reliable instrument for the assessment of connections through the “2I” model.

Keywords—*entrepreneurially-minded learning, connections*

I. INTRODUCTION

“Connections” is one of the three Cs of the “entrepreneurial mindset,” along with “Curiosity” and “Creating Value,” set

forth by the Kern Foundation [1] for their Kern Entrepreneurial Engineering Network (KEEN). The specific goals of our current project are to (a) develop a framework for “connections,” within the KEEN context, drawn from the relevant literature, (b) use this framework to identify specific metrics that might be used for purposes of assessment and (c) identify existing instruments that could be used for this assessment. The current project is an extension of previously funded work to explore the concept of “curiosity”, another element of the KEEN entrepreneurial mindset. As with that work, the eventual goal here is to explore how individual courses and programs can be developed to foster the targeted learning outcome.

This paper summarizes the existing language provided by the Kern Foundation related to “connections” and the entrepreneurial mindset in order to identify common themes in how that concept has been interpreted by the KEEN community. These themes are then combined into a potential framework for “Connections” that incorporates all of the significant components described in that literature. Finally, this paper lays out some potential metrics and instruments that might be used for the purpose of assessment.

II. BACKGROUND

A. Developing a framework for “Connections”

The document “KEEN Engineering Unleashed: Entrepreneurial Mindset Defined” [1] has the following to say about Connections:

CONNECTIONS: Discoveries, however, are not enough. Information only yields insight when connected

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with other information. We must teach our students to habitually pursue knowledge and integrate it with their own discoveries to reveal innovative solutions.

That document also lists example behaviors associated with Connections, which include integrating information from many sources to gain insight and the ability to assess and manage risks.¹

Further discussions illuminating how “Connections” is defined and interpreted by members of the KEEN community can be found in additional KEEN literature. For example, in “The light bulb moment: making connections to gain insights” [1], the speaker discusses “Connections” as insights in which there is an unexpected shift from one story to another as some initial beliefs are abandoned and replaced by a new model which is more accurate and more comprehensive.

The association of “Connections” with “Integration” is another common theme found in the KEEN literature. For example, in “Making Connections: Integrating the Entrepreneurial Mindset in Thermodynamics” [1], the speaker equates “Connections” with “integrating thermodynamics with economic, socio-political and environmental factors when solving problems, something he achieved through using problem-based learning. This association of “Integration” and “Connections” was noted previously in the language used to define the entrepreneurial mindset.

Finally, it is clear that the goal of integrating information to provide insight is designed to lead to innovative solutions to complex problems. That goal is explicit in the defining language for “Connections” as an element of the entrepreneurial mindset. In earlier literature from KEEN the term mindset was defined as “A mindset transcends a single area of study, encompassing the entire educational experience – technical and broadening studies, experiential learning, and institutional culture.” The idea of transcending clearly includes integrating information and experiences in a way that is synergistic (providing insights) and not just additive.

Our reading of the KEEN literature therefore suggests an interpretation of “Connections” as a construct with three core elements. Parallel to the “3C” model for the entrepreneurial mindset, we propose a “2I” model for “Connections” consisting of *Integration* and *Insight*. In other words, the ability to draw connections is defined as the ability to integrate new information in ways that provide insights that may lead to innovative solutions. From that point, we have begun to identify metrics and instruments to assess each facet of “Connections” as part of the entrepreneurial mindset.

B. Identifying Relevant Metrics

Ideally, there would be a valid and reliable assessment to complement each aspect of a framework for “Connections.” There is a strong preference among our anticipated faculty audience for metrics that may either a) be easily deployed outside of class or b) leverage existing student work. Therefore the metrics outlined below give preference to self-report surveys that may be given to students on-line outside of

class. There is also one metric that uses an in-class activity that complements existing activities in design-based courses.

III. REVIEW OF POSSIBLE ASSESSMENT INSTRUMENTS

Gauging students’ ability and progress on making connections requires some means of measuring the two related elements of Integration and Insight. This section explores existing metrics and instruments that might be used.

A. Integration

We operationalize “integration” as being able to draw from a range of knowledge and experiences to develop a correct and lasting mental model. There is some literature on the concept of integration which is expressed using different terms.

- Work at Purdue by Senay Purzer has identified the concept of an “Associative Thinker”, which has been identified as a key characteristic of entrepreneurial thinking [2]. This can be thought of as “Grabbing two seemingly unrelated things, putting them together and coming up with a third.”
- Menold et al. [3; 4] provide information related to this characteristic.
- Another potential source is Ragusa’s ECPII instrument [5] which has a sub-scale that looks at engineering fluency. This scale is defined as a student’s level and depth of understanding of diverse aspects of the engineering discipline.
- Lattuca et al. [6] and more recently her former student Knight [7] have looked at interdisciplinary competence. On the instrument used by Knight, one of the subcategories is Broad and Systems Perspectives. This includes understanding how non-engineering fields can help solve engineering problems; applying knowledge from other fields to solve an engineering problem; and understanding how engineering solutions can be shaped by environmental, cultural, economic, and other considerations.
- There has been work over the last decades in systems thinking that may be useful in measuring insight. In brief, systems thinking considers more than one’s own immediate job or task and allows an individual to place their contribution in the larger connected system in which they work. There is an available concept inventory that measures basic knowledge of systems thinking [8] as well as a validated Systems Thinking Scale that has been used with medical professionals [9].

Table 1 summarizes possible approaches to assessing characteristics associated with integration.

TABLE I. CONCEPTS OF “INTEGRATION”

Char. name	Measures		
	Instrument	Definition	Ref.
Associative Thinker	Brainstorming/ Grouping/ Integration Activity (described below)	Joins or connects together ideas or facts from different domains or experiences.	[2]
Engineering Fluency	Engineering Creativity and Propensity for Innovation Index	Student’s level and depth of understanding of diverse aspects of the engineering discipline	[5]
Broad and Systems Perspectives	Educating the Engineer of 2020 Student Survey	Understanding how others solve engineering problems; applying knowledge from other fields, and understanding how engineering solutions are shaped by broad considerations	[6], [7]
System Interdependencies	Systems Thinking Scale	Systems thinking: The ability to recognize, understand, and synthesize the interactions, and interdependencies in a set of components designed for a specific purpose.	[9]

For “Associative Thinker”, as described in Table 1, we did not have an established instrument. The authors reflected upon this and realized that an assessment for this could be built on common bisociation-based [10] design-thinking brainstorming activities. Based on this suggestion, we developed a pilot assessment called Brainstorming/Grouping/Integration Activity (BGIA) that can be used to assess the facility of a group such as a class for joining ideas from different domains.

At the start of the activity, two apparently dissimilar domains are proposed, such as “entrepreneurship” and “sustainability”. Participants are split into two groups, which then generate as many brief descriptors of activities, attitudes, and concepts as they can for one of the domains, using sticky notes of a given color. The groups then switch and fill out any gaps they see in what has been created by the previous group. By the end of this step, there should be many notes for each domain, each on its own color of sticky note. Step two in the process is to collaboratively group these notes into themes that transcend the original domains – each theme should describe a collection of sticky notes of both colors. Finally, the group is asked to break into pairs or small groups and write one or more integrative ideas for an activity, project, venture, or service

inspired by one or more of the themes and sticky notes, citing where these ideas are from. These final documents serve as the basis for the assessment in three categories according to the following rubric:

Quantity

How many integrative ideas are there?

Novelty (0-3, each integrative idea, as described above, is evaluated separately)

0 – The integrative idea is unrelated to the prompt

1 - The integrative idea is obvious

2 - The integrative idea is obvious to people who know the area but clearly new for the person who is brainstorming

3 - The integrative idea is a completely new idea; a reader goes “wow” in looking at it...

Integration (0-3, each integrative idea, as described above, is evaluated separately)

0- There is no relation of information from the two domains; one may be left out entirely for example.

1- Elements from two domains are present, but somewhat superficially. One domain is represented very heavily while the other is not.

2- Both areas are significantly represented in the integrative idea. They are interconnected, and are each essential. Both domains are leveraged in the integrative idea.

3- Disparate elements have combined to form a new way of looking at things. The integrative idea is generalizable. The integrative idea cannot exist without elements from both domains, and it creates an alternate approach for looking at things within this area. A new model.

The BGIA assessment has been piloted in both workshops [11; 12] and classes, and shows promise as both a formative and summative evaluation of integration and associative thinking.

B. Insight

The operational definition of insight is to gain new knowledge in a way that allows it to connect to prior knowledge and to be used in the future. This requires that insights are organized into schemata, or a mental organizing structure. This is admittedly a difficult factor to measure and there are likely a variety of instruments that measure some aspect related to insight without effectively capturing the KEEN meaning. Some options are shown in Table 2. Possible measures are:

- “Insight” might also be linked (weakly) to “reflexivity” in the Lattuca reference [6]. There has been considerable work looking at the role reflection plays in learning and recognition of one’s own biases. Some reviews [13] and instruments exist that are reported to

have good validity. One of these is the Reflection-in-Learning Scale (RLS) by Sobral [14].

- In addition, “insight” might be linked (again weakly) to “Ability to conceptualize and develop new and better solutions based on existing need areas” identified in “Engineering Design” [15].
- Another research area which may be fruitful to investigate is that of threshold concepts. These are described as “...akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress.” [5] The work on threshold concepts is not well established yet, but may be useful for looking at insights within a discipline. Some initial instruments do exist.

Table 2 summarizes characteristics and possible assessments for the aspects of insight.

TABLE II. CONCEPTS OF “INSIGHT”

Char. name	Measures		
	Instrument	Definition	Ref.
Knowledgeable	None available	Possesses information, understanding, or skill that you get from experience or education	[2]
Reflective	Reflection-in-learning Scale	Disputed-reflection as a process linked to experience “that reconstruction or reorganization of experience which adds to the meaning of experience.”	[6] [14]
Threshold Concepts	A variety of early-stage instruments have been developed but validity and reliability are currently uncertain	“...akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding or interpreting or viewing something without which the learner cannot progress.”	[16] [17]

To assess insight, the authors constructed a hybrid survey instrument by first collecting the relevant sub-scales of the instruments described in Tables 1 and 2. This list of questions was then reviewed by a focus group drawn from the KEEN Assessment Working Group, who rated questions on relevance to the proposed model. Using only questions rated as relevant by the majority of respondents, the current instrument consists of 22 questions as our draft scale. While “insight” might better be assessed by an activity similar to BGIA, we are sensitive to the amount of class time that might be available for these

assessments. Complemented by the BGIA, these two assessments could provide a holistic measure of connections ability and propensity for students.

C. Other Considerations

Initially, the “2I” model was a “3I” model incorporating “Innovation” as the third I. Menold et al. [3; 4], directly looks at a wide variety of ways to get at “innovation”. This facet has the richest literature to draw from, but also sits at the interface between our present focus on Connection and another aspect of the entrepreneurial mindset, Value Creation. In the previously mentioned focus group, participants felt strongly that this element was a poor fit for the Connections assessment. A sample of possible constructs for “innovation” from Menold et al. [4] includes a number of items already addressed above, such as knowledge and associative thinking, while also including a number of elements that are more clearly associated with value creation such as “market and business savvy.” Therefore, our efforts are focused on assembling an assessment that centers on the combination of Integration with Insight.

IV. SUMMARY AND FUTURE WORK

We have completed an initial survey of the relevant education literature to identify traits which might be used to define “Connection” as part of the entrepreneurial mindset. In this phase of the project, the goal has been to establish one or more theoretical frameworks within which to view Connection. We initially proposed a 3I model (Integration, Insight and Innovation) as a way to operationalize “Connections”. Based on further work with a focus group, we now propose a 2I model centered on Integration and Insight. Another suggestion that emerged from the focus group was to include aspects of building and maintaining interpersonal connections into an operational definition. As we continue this work, the literature survey will be expanded and team members will continue to meet to discuss the pros and cons of different frameworks and traits associated with Connections. We anticipate operationalizing these into a draft set of Connections traits, similar to how motivation and situational curiosity were used in our previous study in which we operationalized “Curiosity”. We also intend to capture pilot data from students with both the BGIA and our survey instrument.

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