FROM COMPLAINING TO THE ASSOCIATE DEAN TO LEADING INNOVATION: THE ROAD TO UNDERSTANDING WHAT MY ENGINEERING STUDENTS ARE EXPERIENCING WHEN LEARNING FOR ENTREPRENEURSHIP

Alex Bruton, PhD, PEng, MBA
Schulich School of Engineering, University of Calgary
alexander.brunton@ucalgary.ca

Abstract – *In this paper I provide a personal narrative, early exploration of, and directions for work being carried out to reframe and more deeply understand the learning taking place in my engineering entrepreneurship classroom. The first contribution is a new pedagogical lens being used to frame the learning students need to do explicitly in terms of the key competencies, barrier concepts, and learning thresholds my students need to master (as opposed to the time-based tables of content and syllabi we normally use). The second contribution is a description of the game-like dynamics that have resulted from this competency-threshold lens, and which seem to have, in turn, encouraged a switch in focus from ‘getting grades’ to ‘leveling up’ by mastering the competencies between and at each barrier or threshold. I also describe how this new lens seems to have focused me and my students more on their personal processes of building knowledge than just the products of the learning normally assessed. The third contribution is a proposed research methodology and novel approach to data collection that together promise to provide a rich narrative and significantly deeper understanding of my students’ learning experiences. I share insights gained to date on this research journey, along with steps for further research.*

Keywords: Entrepreneurship; design thinking; threshold concepts; troublesome knowledge; liminal spaces; competency-based curriculum design; game-based dynamics.

1. INTRODUCTION

I am fascinated by my engineering students because they seem to approach learning for entrepreneurship in different ways than others do, and because, generally, they all seem to encounter the same or remarkably similar challenges along their learning journeys. For example, the engineering students I’ve taught in my school seem to struggle with almost exactly the same barrier concepts and troublesome knowledge as each other, and, importantly, have ended up

being caught in ‘liminal’ or ‘stuck’ spaces that appear to be markedly different than those of the people I teach and coach in other disciplinary areas. The overall goal of this paper is to share and reflect on work being done to get beyond my own classroom-based observations of this phenomenon toward gaining a deep and sharable understanding of what my students are actually experiencing – expressed in their own words from their side of the teaching and learning fence.

1.1. Motivation

I help people learn to innovate and, in recent years, I have been fortunate to do so with thousands of learners in places ranging from Moscow, to Mexico, to Seattle, to Waterloo. I’ve worked with students, startups, corporate innovators, educators, and the directors of institutes and centres of entrepreneurship. I’ve done so in high tech, low tech, for-profit, and for-benefit contexts. I’ve had the chance to give an invited talk at Google during one of their innovation weeks, and I have spoken and delivered workshops with employees at companies large and small. And while my college and university students have included engineering students, they have also included a cross section of students from business, science, and other academic disciplines; I’ve been a tenured faculty member in both a business school and an engineering school, for example.

I share all of this to try and provide a meaningful context for the observation that my engineering students seem to be different from most of the rest of my other learners in important ways that motivate the work being reported here. The fact that they respond differently is both personally fascinating to me as a teacher, and potentially important to educators in our field. And, as outlined in this paper, it informs my broadest problem of practice, drives the central research questions this work is designed to address, and has inspired the use of a new approach to designing, delivering, and assessing that seems to put the focus on teaching and learning for mastery instead of test scores.

1.2. My Local Context and Problem of Practice

For three years in a row now, I have taught a highly experiential course called *Engineering Entrepreneurship* to fourth year engineering students at the Schulich School of Engineering, almost every one of whom reports having never previously taken a course in the areas of entrepreneurship, innovation, or creativity. I have found it to be remarkably consistent that they stall out at certain key points in their learning journeys – almost every one of my students gets stuck at almost exactly the same places, even though the course continues to progress week after week. This semester I am also teaching parts of the same course to a class of graduate students in our school, and, so far, I have observed them stumbling at the same places on their journeys.

For context, examples of typical barrier-causing concepts in entrepreneurship and innovation are shown in Figure 1 together with the statements a student might make upon truly mastering them. Some of these concepts can be true *threshold concepts* as defined by Meyer and Land in [9], meaning that they represent transformative conceptual gateways or thresholds that one can't truly progress beyond without crossing, but that once mastered open up new ways of thinking or working that were previously inaccessible to the learner. Meyer and Land characterize these as being transformative, integrative, irreversible, and frequently troublesome. While some of the examples in Figure 1 are of this nature, others will be less significant. However, because they can all represent important and frequently encountered challenges to entrepreneurial learning, I will use the term *barrier concepts* to represent both in this work, and I will speak of learners having to master those concepts in order to cross the corresponding *learning thresholds*.

In my experience in the two engineering contexts in which I teach, my students will often enter a so-called 'liminal' or 'stuck' space when they encounter these kinds of barriers, e.g. of the nature described by Berger in [7]. They will struggle to progress from what they know and can do, to what they need to know and do – and often without even knowing why they are struggling. Different students respond to this differently of course, but, in general for very similar barriers, mine have trouble recognizing the barrier concepts and they have trouble acknowledging the nature of the learning needed in order to overcome them. They struggle to engage with the learning opportunities at the right times. They suffer in subsequent steps because of not having mastered previous steps. And, when they do begin to cross the barriers, each on their own time, I have observed the outcomes of the experience being personally challenging or troublesome. For example, one engineering student team complained to our associate dean because of the ambiguity associated with being in one of the thresholds, and because they feared that their records of high grades might be on the line.

Strategic ideation:

- 'Implementing the right it' is as important as 'implementing it right' • I can deliberately design a big value (highest potential) version of what I'm working on
- I am more resource-efficient if I design / work on the big value version of my concept

Human-centered design:

- Individual humans in relevant contexts inform potential solutions to complex problems • It follows therefore that 'everyone' cannot be my customer • Involving individual humans at all stages of design improves my ability to create and deliver value

Entrepreneurial failure:

- Failure is simultaneously costly and beneficial • It is good to fail - really and truly • And not just because everyone says that it is, or in relatively safe contrived situations

Followership:

- Leadership is not just done by the leader, and followership is not just done by followers • Followers are active not passive, and they are integral to the leadership process • I need to actively follow sometimes too

Shared leadership:

- The organization or venture cannot be solely dependent on one individual to mobilize action or make decisions • Anyone may step up to serve the group's leadership needs • You don't need to be in a formal leadership position to lead

Managing work:

- Results are accomplished through other people • Managing is different from doing

The persuasive pitch:

- An average idea well pitched can gain more support than a great idea not well pitched • A great pitch is a story well told • A pitch serves as a prototype

Fig. 1. Sample barrier and threshold concepts encountered when learning for entrepreneurship

All of this provides the context out of which my broadest problem of practice arises: How can we accelerate and deepen the learning my engineering students do in order to become more entrepreneurial?

1.3. The Situation

We most often design curricula and assess learning by taking students through prescribed experiences on a common schedule or syllabus, even in the most entrepreneurial classroom, seminar, incubator, accelerator, or consultant-led session: we go through one topic or activity; we assess it (or perhaps don't); and then we move on to the next.

In that environment, I find that it's not at all unusual that deep enough learning won't happen at all for some would-be innovators. Despite hearing and being able to talk about a key barrier concept in class, in entrepreneurial circles, or at events, for example, a student new to the entrepreneurial mindset might not truly understand, experience, or master the related competencies in time or in a way that helps them advance their work. It's not uncommon for early-stage entrepreneurs to arrive at places of false confidence with key barrier concepts because successful entrepreneurs who have broken through the barriers themselves will hold them up as badges that get repeated or turned into mantras (the ones that make their way into keynote talks and the startup self-help books found on the shelves in airport bookstores). One will find new entrepreneurs talking or blogging about 'failing fast' and 'failing forward', for example, without ever having taken a significant risk or having experienced real failure at anything. The result is that they might understand such concepts at a surface level, but they won't have mastered them deeply enough to move to the next step in their learning journey.

When working with learners, both in practice and in my experiential classrooms, they often can't identify (or properly identify with) what they should be learning next to help improve their specific situation. Even when they're coached, mentored for their stage of development, and provided with a pretty focused curricular path forward, I've worked with nascent entrepreneurs who are remarkably good at ignoring the required tough learning in favor of what is most familiar to them, or the shinier more fun objects in their surroundings. An example of this is a technical team that resists the simple act of testing a product with potential customers – actual humans who might one day buy their product – because they so love developing the technology and are naive enough to truly believe that sales are going to follow if they can just check in and successfully test that next important version of their code.

When learners do really recognize what's needed next, it's often the case that they're not able to navigate the barrier concepts like those in Figure 1 required for crossing the thresholds, either on their own or with the training available to them. When such moments of learning are achieved, I have observed that they occur at different times for different students, depending on their specific learning paths, environmental contexts, and personal experiences. And, as mentioned earlier, the outcomes of the experience in such cases can be personally challenging or deeply troublesome in precisely the ways outlined in Meyer and Land in [9].

1.4. Interventions and Methodology

Over the years I have tried to address all of this in different ways. For example, I have provided more customized feedback and coaching to each individual or team. I have flipped the classroom using online tools in

order to spend more time engaging with each learning situation in the increased time that buys us. I have also tweaked and outright changed the nature of the projects I assign. But on their own, none of these has had the same kind of impact right out of the gate as the solution I am sharing here seems to have had.

Because of the seemingly common stumbling blocks my engineering students face when learning in these contexts, it struck me one day that they might benefit from a much more explicit focus on those challenges. By this I don't just mean pointing out or teaching to those challenges in my mini-lectures, or trying to be ready with more of my time and with key resources if and when the students do become ready. Rather, I asked myself what might happen if I were to design and communicate the whole curriculum around the challenges I knew the students were going to face. What if those challenges were at the centre of things?

As such, I've been testing the hypothesis that we can accelerate their acquaintance with the barrier concepts and shorten the time it takes for them to cross the thresholds by designing, delivering, and assessing the curriculum in a way that *uses the barrier-causing concepts and the notion of the thresholds themselves as the organizing lens*.

This lens on the learning is described in detail in section 2.2 and has begun to afford me a shift from what I normally do, even in the most experiential and action-based project I teach. As described there, this has meant:

- Treating the barrier concepts and thresholds as opportunities for learning rather than as the challenges we expect our students to encounter when doing the learning; and
- Structuring and communicating the project in a visual way according to those barrier concepts and thresholds.

This shift in perspective has resulted in game-like dynamics that are described further in section 2.3. As described there, this has encouraged my students' focus to turn from obtaining grades on traditional assessments to 'leveling-up' to each next set of competencies (in large part as a result of having to reflect on and provide evidence of having gained the prior set of competencies).

These changes have changed the feel in the room and they have focused my students on their personal *processes* of building new knowledge and not just on the *products* of the learning I normally assess.

Methodologically, all of this has resulted in and benefited from the coming together of a few things in my professional life. The first is an approach to curriculum design in which I've been coaching other faculty members as the Faculty Director of the USASBE Teaching and Learning Scholars Program [3]. This literacy-threshold-competency approach to curriculum design helps re-cast a teaching and learning activity in terms of the barrier and threshold concepts of the nature we've been discussing here. I applied it to my own classroom curriculum for the purposes of this work.

As will be described in section 3, I began this work with the ambition of figuring out whether and exactly how these changes have improved the learning my students are doing; I had visions of proving that what I'm doing now is better than what I was doing before. But although I can certainly speak to that as a result of the experience to date, I have come to realize that all of this is just the first step in a broader more rigorous research process. In section 3, I present a research methodology and a unique approach to data collection that together set the stage for such work. As described there, these are already providing a rich narrative and significantly deeper understanding of the learning experiences of my students – from their own perspectives.

1.5. Significance of this Work

I will discuss the impacts and significance of this work through this paper, and in a summary fashion in section 4. At this point though, I want to share that it has become the first lap in a run I am now compelled to run in order to transform the teaching and learning that goes on in my own classroom. And, that I believe the process and findings of the research are significant for others who teach engineers to lead through entrepreneurship, most notably because it lets the student's own journey or learning arc drive action, instead of (or at least alongside) my teaching journey.

2. RESULTS AND DISCUSSION (1 OF 2): A NEW LENS ON THE LEARNING

The first main result of this work is a significant recasting of the main 7-week class project that my engineering students go through. In the sections that follow I briefly describe the history and nature of the project itself, I share the results of presenting and delivering it to my students through a competency-threshold lens for the first time and I explain the game-like dynamics and focus on mastery throughout the learning experience.

2.1. The Starting Point: The Venture Design Studio (VDS)

I have been working for a number of years to design and openly share curricular tools, methodologies, frameworks, and approaches to assessment that aim to accelerate the learning a would-be entrepreneur should do when faced with the kinds of barrier concepts described above, and I have implemented those in a variety of contexts including university classrooms [1], in online contexts [4], professional and corporate learning contexts [5], and faculty and curriculum development contexts [2], [3].

When publishing about and training other faculty members to implement these approaches, I summarize them as: being experiential in nature; being quite authentic to a 'real' entrepreneurial experience; employing design thinking methodologies; making use of game-based elements; and applying pedagogical analogical models.

In my engineering classes, all of this comes together in an iterative experiential project called the Venture Design Studio (VDS) that spans some 6-7 weeks and counts for 50% of the final grade in the course. It has the students learning both individually and in teams by designing new ventures, and it requires that they construct and perform their understanding both in front of guest judges and in the community, e.g. they develop idea models and deliver pitches on a regular basis as part of the work.

The experience is high-paced, and open ended, and at times ambiguous – there is no one correct solution and no possibility of doing well on the project through rote learning or through tools they might often use, such as obtaining study roadmaps from a previous semester. The explicit and often-stated learning goal is “to design new ventures that are at the same time highly impactful *and* imminently feasible”. Students understand this, it drives action, and they are given the tools to assess their venture concepts as they proceed. Please consult [6] for further details about this project.

2.2. Shifting to a Competency-Threshold Design

As was described in some detail in section 1.4, one of the key results of this work has been a shift to presenting and delivering the VDS project in a way that puts the focus on the barrier concepts and the learning thresholds.

A sample of the resulting design is shown in Figure 2 where the organizational lens isn't chronological or content-based, e.g. it isn't a list of the activities and assessments the student is going to go through, but, rather, it's based on the elements needed to aid or accelerate someone to mastery. As mentioned in the discussion of methodology in section 1.4, this design came about through application of a literacy-threshold-competency framework for curriculum design. This visualization was also inspired in part by the outcome-space model presented in [13].

I'd ask the reader to imagine being a student and receiving Figure 2 instead of (or alongside) a standard course syllabus or table of contents, and that your teacher's framing of success in his or her class was consistently focused on this visual representation of idealized learning journey. You would see pretty readily that your success depends on five levels of mastery, and that each of those corresponds to different levels of competency in two dimensions. The horizontal axis communicates the need to progress from an ad-hoc or linear design process to a full double-loop integrated design process, for example. The vertical axis communicates the need to progress to deep in-context understandings of the humans for whom you are designing change, and situated in their contexts.

This lens on the design is meant to allow the teacher to talk to their students about the *barrier concepts* and encourage them to challenge their students to master each in order to cross the corresponding *learning thresholds*. In doing so, it makes those explicit and central to the overall learning experience.

Fig. 2. An example of how the Venture Design Studio was presented using a competency-threshold design (From [6])

2.3. A Game-Like Dynamic, and a Focus on Mastery and the Learning Process

With Figure 2 in hand, I was pretty excited to begin teaching my engineering students again. And indeed, I noticed some changes right away. Out of the gate, the most significant change was the way I began to think and talk about the learning we were doing in the classroom. With the curriculum expressed in terms of levels of competency

like this, it wasn't long before I realized I could talk to my students about 'leveling up'. The VDS project has always been delivered in an iterative manner, so it is natural for me to talk about the work we 'covered last iteration' or 'will cover next iteration'. But I found I was able to go further than this and talk about the iterations as levels in a game. I opted to be quite explicit about that, explaining that I had designed the experience to be game-like on purpose, and that the game was meant to help them think about and get

good at the things most people don't think about. I told them that getting better at the game would help them become more entrepreneurial.

In turn, I found that my students were very open to the game-like dynamic. This was still a class project and it's no immersive video game; don't get me wrong. But it has provided a very natural opening for talking about the levels of competency they need to master in a way that my students don't mind talking about them. Our conversations are not about me providing a boring reminder of the desired learning outcomes, for example. Rather, I find that they are more often than not prompted by the students asking me for clarification of what the learning outcomes are so that they can then provide the evidence required to level up.

Importantly, I have noticed that the competency-threshold lens and game-like dynamics have also provided me with a tool by which to shift the focus from the *products* of the learning (e.g. in the bigger picture, how impactful and feasible is the new venture you've been designing?) to the *process* of learning (e.g. what did you do to design it, and what was the experience like for you?). In order to succeed at 'leveling up', for example, I can require my students to describe and reflect on what they did and what it was like for them. This is framed as a requirement of the game but it's actually providing them with an important lens that I believe strengthens the learning itself. This is described further in section 3.

3. RESULTS AND DISCUSSION (2 OF 2): DESIGNING RESEARCH TO UNDERSTAND WHAT THIS KIND OF LEARNING EXPERIENCE IS LIKE FOR MY STUDENTS

I believe that what I have presented here so far is useful and important for other educators on its own. However, it doesn't tell the whole story. As one does in the early stages of an exciting project, I began this one with all kinds of ambitions around the kinds of research questions it would allow to me to answer. While my classroom experience so far has reinforced that this new lens on learning does provide an important practical opportunity for inquiry, e.g. I'm seeing and hearing things every day that are new and exciting to me as a researcher, it has also helped me realize how much we don't yet know about what it's like to be on the student side of such a teaching and learning experience.

As such, I propose that the second main contribution of this paper comes from the work I have begun to develop a thoughtful educational research design that will allow me to dig deeper into what's really happening for my students, and to share findings with other educators that will inform their teaching practices. The following sections describe that work so far.

3.1. Research Ambitions and the Questions About Student Learning That I Can't Answer (Yet)

The Venture Design Studio project as it is delivered today represents many years of work, and wow – do I ever have research questions, especially with this new lens on it! To name a few examples in the bigger picture, I'd absolutely love to know:

1. Does a design thinking process and the method by which students assess themselves, such as those used in the VDS result in better student-designed ventures? (a 'what works?' question in the typography of SoTL questions provided by Hutchings in [8])

2. Does the use of barrier concepts as a curricular organizing lens, e.g. as described here in section 2 and Figure 2, really accelerate the student across learning thresholds (also a 'what works?' question)

3. Do engineering students really respond differently to the barrier concepts and thresholds as I suggested they do in section 1? (a comparative 'what is?' question)

4. Could the approaches and frameworks described here improve learning in an organizational context outside the classroom? (a 'visions of the possible' and possibly also a 'what works' question)

5. Could they shape the ways in which practicing entrepreneurs think and go about their work? (a 'new conceptual framework' question)

Based on my previous experiences with educational research, I suspect there is much too much in these questions for one project. Despite having spent a lot of time with learners in the various contexts I've described, I don't yet have the tools in hand to design a study through which one could answer these kinds of questions in a definitive and completely generalizable way (such is the difference between research in education and research in my home disciplines of engineering and business).

My experience so far and the intended focus of the work on barrier concepts and on helping my students across the learning thresholds have both suggested to me that the best first step is to try and more deeply understand what is actually happening for students in the classroom.

3.2. A More Focused Central Research Question

Because of the realizations outlined above, I have narrowed my central question to the following with which I believe I can launch deeper iterations of this work: What do engineering students experience when learning for entrepreneurship through a design thinking based experiential curriculum organized by barrier concepts and learning thresholds?

Narrowing and revising a research question may not seem like a big contribution, but I want to propose that it's actually a fundamental step forward in this work, worth sharing here with others for several reasons. First, the question itself still serves the goal of addressing the problem of practice outlined in section 1.2, i.e. it directly supports the broad goal of accelerating the learning my engineering students do in order to become more entrepreneurial.

Second, this revised version of my question implies an important shift from the kinds of questions posed in section 3.1. It's now of the exploratory 'what is?' form outlined by Hutchings in [8], meaning that at this stage my aim is not to prove the effectiveness of any approach. Rather, it means that I'm really only after gaining as deep an understanding as possible of what is happening for my students – while they learn, and from their own personal points of view. It becomes about their learning.

Third, the nature of the VDS project makes answering this kind of question feasible, especially the look-back reflections students do after each iteration (see 3.3.2).

Fourth, I believe a lot can be learned by taking this approach, and that doing so with such a focus on student learning might actually raise and answer a number of related questions teachers in our field don't yet know we have.

From the work of Miller-Young & Yeo in [10] I find encouragement in starting this project with a move away from generalizability toward gaining and sharing a deeper understanding of student learning experiences in the name of exploring for phenomena that may not have been anticipated and by trying to understand what is truly happening for the entrepreneurial learner. In turn, I propose that this will help us better serve the learning experiences our students in the future.

3.3. A Research Methodology, and a Novel Approach to Data Collection

After landing on the revised research question described in section 3.2, I began the work of designing a study that will answer it. This has resulted in a draft methodology and some data sets that I believe have a unique potential for providing insight into the learning experiences of my students. Even though these are in the early stages, I share them here as a contribution of this work because they may not be obvious to a reader accustomed to engineering research.

I also share them because they represent a shift in my own research. To date, most of my work and publishing in education for entrepreneurship has been aimed at other teachers on the topics of how I teach, on how to teach, or on how one can think about their teaching. Yet I am relishing the chance to just stop and listen, and to try and deeply understand what my students are experiencing in my own classroom.

3.3.1. Methodological Approach. Conceptually, and trying to situate the work in the framework for the Scholarship of Teaching and Learning (SoTL) advanced in [10], I am coming at the next stages of this project with a social constructivist perspective on the nature of the learning taking place in my classroom, and, broadly speaking, I am expecting to use interpretive methodologies to help frame and answer the central question I've posed.

While I expect things to evolve within those boxes as I design the study, I'm currently expecting to use qualitative methods such as classroom ethnography to interpret the data already being produced by my students as part of the VDS project.

3.3.2. A Unique Way of Collecting Data. The Venture Design Studio project includes something called a 'look-back learning reflection' that is already being completed by the students after each of the five design iterations. These are a cross between a (several) minute-paper and a mini structured video interview. They are already fully automated using tools provided to us by The Straight Up Business Institute in the form of a recorded video interview and online survey, with the ability to quickly review and analyze the data on the back end. The result is that I can share one link with my students at the end of each iteration, and, in doing so, quite effortlessly collect a rich data set about their learning experience.

Here is a sample of the look-back learning reflection for the first of the five levels in Figure 2:

https://educatorspro.myvideointerview.ca/questionnaires/10912-level-1/people/new?locale=en&preview_key=xqpbac0aj4brpk32

(This is just a preview shared to help the reader of this paper understand the nature of the tool; no data are actually collected.)

This formative reflective self-assessment process takes place at key points over the duration of the project. As discussed earlier, it is framed as being required to 'level-up' at the end of each iteration. The students use it themselves as part of a final reflective project in the course, i.e. as part of a more summative assessment task, they are asked to use the same reflections to look themselves at how their own learning has evolved.

3.3.3. Other Related Thinking and Comments on Methodology. Further, my thinking today is that follow-up interviews of a less structured nature could also be conducted with members of the class in order to more deeply probe areas of interest that arise from the look-back learning reflections. And that I will analyze those data with similar ethnographic methods. I refer the unfamiliar reader to the work of authors such as Watson-Gegeo [11] and Webb [12] for more on these kinds of research interviews, approaches to classroom ethnography, and associated methodologies.

4. IMPACTS AND CONCLUSIONS

I have addressed the impacts of this work throughout the paper, so in the following I wish to conclude by focusing the reader on some of the key impacts and takeaways.

4.1.1. Impacts of Using the Competency-Threshold Lens. Perhaps the biggest impact of the new lens on the learning process described in section 2 is that both my

students and I have become less focused on the teaching journey (e.g. characterized by the syllabus, topics, tools, activities, and assessments) and more focused on each student's learning journey (e.g. characterized by what is actually happening and what needs to happen for them). We're all thinking much more explicitly about these, which is exciting. Further, since assessment drives behavior, I am pleased to report a better balance of focus on between the *products* of the learning (e.g. the new venture under design that is intended to be both impactful and feasible) and the *process* of the learning (e.g. via the look-back learning reflections carried out at the end of each iteration). Putting the barrier concepts and thresholds out as navigational waypoints seems to be a powerful aid to learning.

4.1.2. Impacts of the Data and Methodological Approach. At this point I don't yet have the ethics approval required to share some of things I'm seeing in the data being collected using the tool described in section 3.3.2, and such approval will likely only allow me to do so in an aggregate way that protects the anonymity of the students. However, I want to signal in these final remarks just how incredibly rich those data are proving to be. By looking at and reading what the students describe and by watching the videos they are producing at each of the levels in Figure 2, I'm learning things about what's happening in my classroom (and about works and doesn't work for my students) that I don't believe I would have ever considered otherwise. In turn, these are providing insights into the learning environment and identifying areas for further exploration that are very exciting. Further, I believe insights gained from this data will help formalize the observations I shared in the abstract and introduction to this paper about why my engineering students run into barriers that are different from those of my students in other disciplinary areas, and will shed light on the nature of their shared 'liminal' experiences.

4.1.3. In closing. On the classroom teaching front, this work has already helped shift the focus away from progressing through activities that produce a grade, toward activities that also encourage individual learning through mastery of barrier concepts. On the research front, the activities outlined here and those I expect to undertake in the next steps of this work constitute a different kind of scholarly journey for me that has potential to improve my own teaching and to inform our field.

Acknowledgements

I gratefully acknowledge the Schulich School of Engineering at the University of Calgary for providing the funds to make my travel to this conference possible, and for providing the curricular environment in which this work was carried out – both while I was a sessional instructor and more recently as a senior instructor. The

Straight Up Business Institute is thanked for providing the tools through Creative Commons that enable the Venture Design Studio approach, for use of the tools for the look-back learning reflections that enable the data collection, and for the competency-threshold design being used.

References

- [1] Bruton, A. (2010). The Venture Design Studio: From Planning to Design Thinking and Collaborative Knowledge Creation for Highly Innovative New Venture Conception and Communication. Annual World Conference of the ICSB, Cincinnati, June 2010.
- [2] Bruton, A. (2016). Deliberate Opportunity Design: A practical integrative product and business design framework to enable new frontiers in fostering innovation and entrepreneurship. *USASBE Annals of Entrepreneurship Education & Pedagogy*, Vol. 2, 176-199.
- [3] Bruton, A. (2017). The USASBE Teaching and Learning Scholars Program. Accessed at: <https://www.straightupbusiness.institute/for-educators/go-deep-scholars>
- [4] Bruton, A. & Le, M. (2018a). The Straight Up Business Institute's Idea Maker Course. Accessed at: <https://www.straightupbusiness.institute/courses/idea-maker>
- [5] Bruton, A. & Le, M. (2018b). The Straight Up Business Institute's Offerings for Teams. Accessed at: <https://www.straightupbusiness.institute/for-teams>
- [6] Bruton, A. (2018). The Venture Design Studio. Accessed at: <https://www.straightupbusiness.institute/tools/venture-design-studio>
- [7] Berger, J.G. (2004). Dancing on the threshold of meaning: Recognizing and understanding the growing edge. *Journal of Transformative Education*, 2(4), 336-351.
- [8] Hutchings, P. (2000). Approaching the Scholarship of Teaching and Learning. In *Opening Lines, Approaches to the Scholarship of Teaching and Learning*, Carnegie Foundation for the Advancement of Teaching, pp. 1-10.
- [9] Meyer, J., & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education*, 49, 373-388.
- [10] Miller-Young, J. & Yeo, M. (2015). Conceptualizing and Communicating SoTL: A Framework for the Field, *Teaching & Learning Inquiry*, Vol. 3, 37-53.
- [11] Watson-Gegeo K.A. (1997). Classroom Ethnography. In: Hornberger N.H., Corson D. (eds) *Encyclopedia of Language and Education*. Encyclopedia of Language and Education, vol 8. Springer, Dordrecht
- [12] Webb, A. (2015). Research Interviews in the Scholarship of Teaching and Learning, *Transformative Dialogues: Teaching & Learning Journal*, 8(1), pp. 1-8.
- [13] Zoltowski, C. B., W.C. Oakes, and M.E. Cardella (2012) Students' Ways of Experiencing Human-Centered Design, *Journal of Engineering Education*, 101(1), pp. 28-59.