Blending Entrepreneurship and Design in an Immersive Environment

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Abstract

Integrating entrepreneurial thinking into engineering education is a growing area of interest. Existing programs have created content for courses offered during the normal semester where traditional modes of assessment, such as grading, have been used to evaluate learning. Within this research the authors explore another style of offering entrepreneurship and design within engineering education. The authors present their findings and experience in offering design-based immersive learning experiences that are outside of the traditional classroom setting. This paper evaluates whether students involved in the design-based immersive learning experiences developed knowledge pertaining to design and entrepreneurship as evidenced through comparative analysis of student reflections and authoritative literature in the subject area.

Introduction

Since the end of the 19th century, there has been a divide within education between traditionalist and progressive philosophies. In 1938 John Dewey, one of the most important educational voices of our time, presented his philosophy of education as experience (Dewey, 1998). In his work he outlines the importance of establishing a firm base that traditionalist forms of education can nurture. He also calls for the progressive style of tying those facts to experience. Since this time educators have been trying to create educational curricula at various levels that incorporate baseline knowledge with experience (Kolb, 1984; Savery and Duffy, 1995; Bonwell and Eison, 1991; Kolodner, 1993; Boud and Feletti, 1998).

Historically, universities have followed traditionalist methods of instilling a broad range of information into the minds of their students. Within technically minded universities and colleges, however, there has been even more focus on providing the technical knowledge base. Today, the field is realizing the importance of developing engineering students who are technically proficient, but who are also inherently curious, who can infer and develop connections between ideas, and who are capable of adding or creating value within their academic and professional pursuits (Kriewall and Mekemson, 2010). Curiosity, connections, and value creation are central
to instilling the entrepreneurial mindset in students (KEEN, 2014). It should be noted that the entrepreneurial mindset is distinct from skills and knowledge needed to execute and entrepreneurial venture, and is rather a set of attitudes. Engineering educators are trying to understand how to best foster the development of the entrepreneurial mindset in our students. There are progressive programs that have moved away from traditional models to try to accomplish this task, but even the more progressive schools still have the foundation of classrooms and faculty members as a means of conveying information.

Immersive learning experiences, on the other hand, offer a different approach. Immersive learning experiences often take place outside of the classroom setting in a dynamic environment. While the literature exploring immersive learning with engineering education is still being developed, personal experiences with immersive learning programs have shown promising results on impacting student learning. The KEEN Winter Interdisciplinary Design Experience (K-WIDE) at Bucknell University and the Interdisciplinary Design Experience (IDEX) at Ohio Northern University are examples of design-based immersive learning experiences that seek to instill the entrepreneurial mindset in participating students (Kim and Tranquillo, 2014). Knowledge and skills are presented, but the entrepreneurial mindset is the focus. These programs engage students in a limited duration, immersive, off-semester experience that challenges them to develop and build new products that address a large social problem (e.g. Urban Infrastructure, Human Weight, Building Energy). The large scope of the initial problem is intentional in that it allows students to experience how to integrate both design thinking and entrepreneurial thinking.

While the day-to-day logistics of the interdisciplinary design experiences offered at both schools are slightly variable, both programs offer 10 days worth of immersive design experience inspired by a simple two-word phrase (e.g. Building Energy). Each program followed a consistent curriculum that engaged students throughout the entire design process. Curriculum components included: orientation to the program, safety and shop training, team building, photo essay assignment and sharing, introduction to reflection, interdisciplinary design, problem identification, topical expert presentation, functional decomposition and physical embodiment, physical realization of functions, alternative solutions, concept to embodiment workshop, design concept refinement, multiple design reviews, quick pitches, feasibility, lots of build-it time, and a final design showcase.

Each of the curriculum components was introduced to the students by one of the faculty facilitating the program. Each curriculum component often included a short presentation (15-20 minutes) followed by an activity. The design reviews were often on going and informal, but did include at least two formal reviews by faculty and technicians during the program. The build-it time occupied the majority of the final five days of the program, with the quick pitches (one to three) preparing the students for the final design showcase. The showcase events draw fellow
students, faculty, staff, and administrators to learn about the individual group innovations. Each group participating in the experience has a prototype and poster on hand to explain their project.

The programs were initiated to couple design thinking to the entrepreneurial mindset. The focus of the program is to teach the process, rather than focusing on the outcome of the project. A student focus on opportunity recognition, customer needs, and field observations of the issue are examples of how the entrepreneurial mindset develops alongside the actual design of the prototype.

While the theory behind this immersive learning program has been detailed elsewhere (Kim and Tranquillo, 2014), this paper explores the student perspective on how engineering design and entrepreneurship are linked through experience. Specifically, this paper utilizes Leximancer (natural language analytics software) to perform comparative analysis of student reflections and authoritative literature to identify themes within the student reflections that overlap with the entrepreneurship and design knowledge base. The outcomes of this research will inform educators as to the utility of design-based immersive learning experiences in blending engineering design and entrepreneurship.

Methods

There are several survey-based methods for tracking mindsets. There are instruments to measure attitudes toward, and interest in, entrepreneurship education (Duval-Couetil et al., 2012); a propensity for creativity and innovativeness (Ragusa, 2011); an understanding of innovation (Purzer and Fila, 2013); technology and venturing self-efficacy (Lucas and Cooper, 2009); and the outcomes and value of programs (Stock and Zacharias, 2011). Survey instruments, however, are rarely open-ended, typically capture only pre- and post- information, and are not naturally integrated into the program (i.e. students are more aware that they are participating in a research study). In a previous study we conducted pre-post surveys as well as coded design concept maps (Kim and Tranquillo, 2014). In this study we analyze data that is integrated into the program for pedagogical reasons first, and only later used as source data for analysis. The form of these data are written reflections that were collected throughout the program. Other forms of reflection were used (e.g. graphics, conversational), but these are not included in the present analysis.

Students were asked to reflect upon their experience in the immersive design programs at several different points during the design process, typically 30 minutes each day. Representative reflection questions included:

- How have you grown throughout this experience?
- What specific challenges did you face?
• Compare your motivation in this program to your motivation in a traditional class.
• What will you do to be uncomfortable in the next five days?
• What should our team focus on between now and 8am tomorrow?
• What is the value proposition for your artifact?
• What is the value proposition for the program?

The questions above are representative in that the authors adapt questions on-the-fly to what we feel students need to think about most deeply. The goal of analysing these reflections is to have a more direct way of assessing the mindset change. All data collection at both institutions conformed to the Bucknell Institutional Review Board.

Over the 2014 and 2015 offerings at Bucknell University there were twenty-five male and fourteen female participants, representing biomedical engineering, electrical engineering, computer engineering, mechanical engineering and civil engineering. Six participants were international students. In the one offering at Ohio Northern University, there were nine male and four female students representing the areas of civil, electrical, and computer engineering. All of the Ohio Northern students were internationals. A total of 209 reflections were collected from students over the three offerings. Individual students contributed multiple reflections from each offering, with reflections occurring over multiple time points. These reflections were used collectively as data inputs to Leximancer for natural language analysis.

Leximancer (http://info.leximancer.com/) is an analysis software program that creates networks of concepts from natural language resources through semantic text mining. Leximancer is a validated lexical analysis platform that has been used throughout academic research. The use of Leximancer across academic areas has been reported in 1000+ academic publications. The software processes text utilizing algorithms that identify lexically related terms based upon the statistical frequency and distribution of co-occurring words in segmented blocks of text (known as epochs). These identified terms become seeds for another algorithm that internally builds a thesaurus from the text resources. The internal thesaurus is then employed to recursively identify a list of weighted concepts from the analyzed text.

The relative co-occurrence of these concepts is then used to create a two dimensional adjacency matrix. Connectedness of concepts within the matrix is used to create a third hierarchical dimension in which parent concepts (known as themes) emerge. The Leximancer software then exports the resulting concepts and themes to create interactive visualizations.

Within the presented analysis, the authors chose to analyze the text using two sentence epochs that split at paragraphs. We analyzed student reflections and authoritative texts from entrepreneurship and engineering design. In all cases each individual text resource was analyzed
using Leximancer to identify the key concepts and themes emerging from the resource. Rank ordered lists of themes are identified for each text resource individually. Analyzed text resources for entrepreneurship included *Teaching Entrepreneurship* by van der Sijde *et al.* (2008) and the *Harvard Business Review on Entrepreneurship* by Sahlman *et al.* (1999). Analyzed engineering design texts included *Decision-based Design* by Chen *et al.* (2013) and *Engineering Design* by Pahl *et al.* (2007). For analysis of the authoritative texts, both resources within each topical area were combined. All of the student reflections were analyzed together to reduce artifacts from specific implementations and demographics of the programs.

After running the first-level analysis for each text resource, the authors screened the generated concepts and excluded certain terms from the concept seed lists. These terms included text identifiers such as ‘Figure’, ‘Table’, ‘Shown’ and the reflection questions themselves. Additionally, derivative terms were merged into one concept (e.g. ‘use’, ‘uses’, ‘using’). Once screening and consolidation were completed, the software was utilized to generate semantic maps that contain themes and the concepts that form those themes.

Interpreting semantic maps requires an understanding of how themes and concepts appear. Closely related concepts form themes that emerged from each text and that are presented within the maps. The name of the theme is in fact the most highly weighted concept within the theme. Graphically, themes are represented by circles that include words to indicate the most important concepts that form that theme. Lower ranking concepts are hidden, but can be exposed through the interactive interface. The larger the circle the more important the theme. The network is also color coded, with hot colors indicating tightly connected concepts within a theme. The networks also visibly demonstrate the relationship between themes using line segments called paths. A path between themes shows how concepts may be related across themes.

**Results**

Semantic maps were created for the three datasets. Figure 1 shows the design map, Figure 2 shows the entrepreneurship map and Figure 3 shows the program reflection map.
Figure 1: Theme maps generated in Leximancer for design textbooks. Circle size indicates relative importance of a theme, while colors indicate the connectedness of concepts within a theme (hot colors means more connected).
Figure 2: Theme maps generated in Leximancer for entrepreneurship textbooks. Circle size indicates relative importance of a theme, while colors indicate the connectedness of concepts within a theme (hot colors mean more connected).
Figure 3: Theme maps generated in Leximancer for program reflections. Circle size indicates relative importance of a theme, while colors indicate the connectedness of concepts within a theme (hot colors means more connected).

To aid in comparison of themes across data sources, Table 1 lists the primary themes for each resource. The given percentage is based upon the percentage of linguistic real-estate of the text that is owned by a particular theme, noting that the top theme is always normalized to 100%. It
should also be noted that while these concepts are not mutually exclusive, they cover the linguistic space of each data set.

Table 1: Summary of the most important themes in the entrepreneurship, design and program reflection data.

<table>
<thead>
<tr>
<th>Design Themes</th>
<th>Entrepreneurship Themes</th>
<th>Reflection Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>model/modeling 100%</td>
<td>business 100%</td>
<td>problem 100%</td>
</tr>
<tr>
<td>design 94%</td>
<td>entrepreneurship 80%</td>
<td>team 97%</td>
</tr>
<tr>
<td>used 48%</td>
<td>ventures 48%</td>
<td>design 72%</td>
</tr>
<tr>
<td>product 45%</td>
<td>product 43%</td>
<td>ideas 65%</td>
</tr>
<tr>
<td>cost 40%</td>
<td>work 27%</td>
<td>learning 63%</td>
</tr>
<tr>
<td>production 24%</td>
<td>learning 26%</td>
<td>different 50%</td>
</tr>
<tr>
<td>solution 23%</td>
<td>students 25%</td>
<td>work 48%</td>
</tr>
<tr>
<td>function 22%</td>
<td>people 17%</td>
<td>need 48%</td>
</tr>
<tr>
<td>system 19%</td>
<td>strategy 13%</td>
<td>product 47%</td>
</tr>
<tr>
<td>effect 7%</td>
<td>sales 12%</td>
<td>able 47%</td>
</tr>
<tr>
<td>parameter 7%</td>
<td>cash 9%</td>
<td>program 17%</td>
</tr>
<tr>
<td>force 6%</td>
<td></td>
<td>course 7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>future 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>value 5%</td>
</tr>
</tbody>
</table>

It is important to note that a theme contains within it several concepts that have a high probability of co-occurring. For example, in the design data, the theme ‘model’ is ranked highly because it co-occurs with the concepts ‘choice’, ‘customer’, ‘utility’, ‘performance’ and ‘alternative’. These are all concepts that probabilistically are related to the theme of ‘model’. For example the ‘customer’ concept strengthens the ‘model’ theme. It is also important to note that the word ‘model’ is serving two purposes. First it is the name of a theme (a group of words). Second it is a concept (a single word or merged group of words). It is because the word ‘model’ is the most connected word in the theme that makes it the name of that theme. Likewise, the ‘business’ theme in the entrepreneurship texts include the concepts ‘opportunity’, ‘planning’, ‘idea’ and ‘action’.

Although each of the three bodies of text are distinct, there are some important commonalities. Each contains as a key theme ‘product’ at approximately the same high level of importance. Both design and entrepreneurship have ‘cost’ as a key theme, while the programs have ‘value’ as a theme. ‘Learning’ shows up as a very important component of both the programs and the
entrepreneurship literature. ‘People’ and ‘team’ are important concepts in both the programs and entrepreneurship. ‘Design’, not surprisingly, shows up very strongly in both the design books as well as the programs. Somewhat surprisingly ‘work’ and ‘learning’ show up in both the program and entrepreneurship books. In both cases it is because ‘course work’ is a phrase that often is used in both the program reflections and the Teaching Entrepreneurship text. Both program reflections and entrepreneurship have future-oriented topics such as ‘planning’ and ‘strategy’, either as themes or as important concepts within a theme. It is interesting that in the reflections, ‘problem’ comes up as the number one theme, but the next most relevant concept within that theme is ‘solution’, which is a main theme of ‘design’. One surprise was that ‘value’ was ranked low in the reflections, despite the instructors dedicating a great deal of the program toward identifying and expressing the value proposition of the product and the program. This realization helped us understand how we might use this analytical methodology in the future to improve upon learning that occurs within our immersive programs.

Conclusions

The goal of this study was a preliminary analysis of student reflections from immersive programs that blend together design and entrepreneurship. One main take-away from the analysis is that semantic analysis of reflections can be used to understand how students are perceiving the experience of intertwining engineering design and entrepreneurship. Also of note is that students have tightly linked ‘problem’ and ‘solution’ within the immersive design experience. We credit this outcome to the time they spend (approximately 30 hours of the program) on understanding the scope and context of the selected problem. We speculate that this investment of time and attention to the problem more tightly aligns the ‘problem’ and ‘solution’ concepts. Another take-away that may not be surprising is that design and entrepreneurship (as well as the student experiences) are tied together through the theme ‘product’. Perhaps more provocative is that the themes in engineering design are not the same as the themes in entrepreneurship, but they share many commonalities at the level of concepts (e.g. ‘cost’, ‘planning’).

There are several limitations of the work. What we have presented is preliminary and we have purposely not decomposed reflections into demographic groups (e.g. majors, gender, team, university, culture). Future work may move down a level of granularity to examine if patterns exist within certain groups. Likewise, the reflections were drawn from the students’ experience within the program. As such, our results provide a situated view of their experience rather than how the experience has impacted them over time or after the experience was over. Related to the timing of the reflections within the program, we lumped all reflections together. However, our observations are that student reflections change as they navigate the program. There may be patterns in the reflection maps as students enter and exit various stages of the experience. Although the programs offered were immersive, our analysis does not directly address the role
that immersion played in the experience. For example, it may be that the reflection analysis
would be different had the learning occurred in a more traditional course format. Again, this will
be a topic of future work.

Our analysis demonstrates that students are learning both engineering design and
entrepreneurship concepts, as evidenced by comparison of their reflections with authoritative
texts. Analysis of student reflections show that the concepts are also coupled together within
their writing based upon the presence of overlapping themes, blending ideas from both areas to
form their mindset. As instructors interested in understanding how content gain (as themes) and
student perception (in reflections) are related to one another, this analytical approach can be used
as a novel way to assess learning. By identifying themes and realizing that some themes were
not present in the student reflections, the instructor can revise their program components
accordingly to facilitate additional blending of entrepreneurship and engineering design concepts
within a design-based immersive learning experience.

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