Opportunity Thinktank: Laying a foundation for the entrepreneurially minded engineer

Prof. Robert Gettens, Western New England University

Rob Gettens is an Associate Professor of Biomedical Engineering and the Director of the First Year Engineering Program at Western New England University.

Prof. Jose Antonio Riofrio, Western New England University

José A Riofrío received his B.S. in Engineering Physics from Elizabethtown College in 2003, and his M.S. and Ph.D. in Mechanical Engineering from Vanderbilt University in 2005 and 2008, respectively. At Vanderbilt, José focused his research in controls, mechatronics and mechanical design. After obtaining his Ph.D., José worked in the Fluid Power industry designing servo-pneumatic control systems for various motion-control applications, such as packaging, automation, and animatronics. In the fall of 2011, José became an assistant professor of Mechanical Engineering at Western New England University, where he now teaches various courses in solid mechanics, mechatronics, and first-year engineering.

Dr. Harlan E Spotts Jr., Western New England University

Professor of Marketing in the College of Business

Opportunity Thinktank: Laying a foundation for the entrepreneurially minded engineer

Introduction

Design projects have become a principal element of the undergraduate engineering curriculum. Recently, using the KEEN philosophy, there is momentum to push engineering education further by fostering an entrepreneurial mindset among students. Providing a basic set of engineering skills in specific specialty areas of study is no longer sufficient. Engineers design solutions for marketplace problems. As such it is imperative that they approach the marketplace in search of opportunities for which they can design break-through solutions. This is the mindset of the entrepreneur. The need for entrepreneurial thinking is pervasive among businesses, which have turned to design firms such as IDEO to develop the next break-through, blockbuster solution for marketplace opportunities.

We focus on opportunity identification and have named our process the Opportunity Thinktank. The "Thinktank" provides the preparation required for identifying great, new design solutions. It involves research that provides a foundation upon which ideation and design can take place. This is an introduction to a different way of thinking than students are used to in their required engineering coursework. Looking for opportunities requires examining the marketplace through an entrepreneurial-minded lens to identify the most pressing problems. This entrepreneurial mindset focuses on understanding and empathizing with the client facing the problem. This understanding provides the foundation on which ideation takes place, we call them "bugs." Bugs, or pain points, refers to situations where consumers, or an organization, have an unsatisfied need that creates a level of frustration. If the opportunity and the client are not fully understood, much ideation and design time will be wasted generating marginal and incremental solutions destined for the dust bin.

This paper outlines a set of seven modules that help to establish an entrepreneurial mindset among undergraduate engineering students. The Thinktank begins with students observing the world around them, identifying areas within their major area of study that create pain points for consumers, business or society in general; this is a micro to macro examination and we will generally refer to any one of these areas as the "client." After identifying opportunities for which a design solution may be suitable focus shifts to understanding their client. Often students, engineering and business alike, are given a problem and they want to start generating solutions before they fully understand the problem or their client's experience. Developing empathy for the client's situation is a fundamental ingredient for creating effective design solutions to the client's problem. Empathy arises from a structured research process that includes traditional secondary and primary research techniques. Collecting backstory information on their client begins with library research to understand the appropriate behaviors to observe and questions to ask. The process then moves to observing the client's pain point experience. Observing is not enough, students need to at least talk with the client and, if possible, experience the pain point themselves. All through this process students are framing and re-framing their problem

statements as they collect additional information. The Thinktank concludes with a final revision and refinement of the problem statement that reflects their empathetic understanding of their client's pain point and preparation for the next phase of the process, ideation.

Why is an entrepreneurial mindset important?

The Kern Entrepreneurial Engineering Network (KEEN) foundation has set as its objective to establish an entrepreneurial mindset within engineering programs. This entrepreneurial mindset encourages engineering students to combine the technical skills learned in their traditional engineering coursework with a mindset to "create extraordinary value for others." This mindset is comprised of three critical factors, including: Curiosity, Connections and Creating value. [1]

Curiosity focuses on the rapidly changing environment in which we live. It is important for engineers to have an "insatiable" curiosity reflected in constantly questioning and wondering about the world around them. Curiosity is evidenced through *Demonstration* and *Exploration*; a demonstration of constant curiosity and exploration through a "contrarian view of accepted solutions for consumer frustrations. [1]

Connections focuses on the pursuit of knowledge and the development of insights that lead to opportunity recognition. This characteristic of the entrepreneurial mindset emphasizes the collection and *Integration* of information, as well as understanding how to *Assess* and *Manage* the associated risks of different opportunities. [1]

Creating value focuses on the development of innovative solutions that create extraordinary value for people. It is through the processes of Curiosity and Connections that engineers need to develop an empathetic understanding of consumers and the frustrations they feel so that they can create these innovative solutions. A characteristic associated with creating value includes *Indentifying* opportunities to create value. Creating "extraordinary" value is not an easy process. It requires a lot of time and effort, students must learn that they have to Persist (another KEEN characteristic) through the process and learn from their failures. [1]

Genesis of an Idea

The genesis for the *Opportunity Thinktank* was a pain point experienced in our engineering program: ideas for student design projects were becoming stale, reflecting little creative thought. The authors felt that emphasizing the early stages of the problem solving process would better prepare students to recognize opportunities and develop more interesting and creative solutions. Energized by the active interest shown by the Kern Entrepreneurial Engineering Network (KEEN) in the entrepreneurial mindset, the Opportunity Thinktank was born. Supported by the Kern Family Foundation, the mission of the KEEN organization is to,

"… graduate engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work."

Thinking like an entrepreneur is a stark departure for an engineering student enrolled in programs founded upon mastery of a highly specialized skill set in preparation for that first engineering position out of college. This type of thinking requires a shift from the concrete and tangible world of skills to a more abstract, and some perceive as soft, world of the consumer mindset. It is a mindset that is less about how you create solutions to problems to one of understanding for whom you are designing those solutions.

With the KEEN initiative as a starting point, creation of the Opportunity Thinktank drew upon the concept of Design Thinking, popularized by the design firm IDEO and the Stanford University Institute of Design. Design thinking, as well as other problem solving models, is a process with well-defined stages that need to be followed to optimize the generation of effective solutions. Different from other problem solving processes, Design Thinking has been adapted to encourage the development of empathy for the client's problem situation. It is this empathy for the client that is important to the entrepreneurial mindset. Entrepreneurs develop solutions, if successful, to market needs that people value.

An issue arises that transcends a student's major and applies to almost everyone. This issue has been characterized as "jumping to solutions." People, in general, are eager to solve problems. In one class activity it was observed by the authors that a team of engineering and business students were reviewing pain points generated by the team. The process was to select a small group of issues for further study. This group, however, had a lengthy discussion of possible solutions to each pain point before achieving complete understanding of the problem.

Whether it is an empathetic drive to help someone or an ego-based drive for self- esteem or a drive to "just get the problem done and move on," there is a strong motivation to come up with an answer as quickly as possible; and, for many undergraduate students the focus is finding the one "right" answer to get a good grade. Often the speed with which solutions are generated over shadows the students' understanding of the problem. As noted above, an important reason for introducing the entrepreneurial mindset into engineering programs is to identify opportunities and develop solutions that create value in the marketplace. This is difficult to do if one does not fully understand the problem, or pain point.

Another issue that arises relates to the focus on ideation. The direct connection that is associated with ideation and developing solutions can create the perception that this is the most important, one and only, part of the process. Students often say they are asked to brainstorm ideas in class activities with little preparation or instruction. The authors decided that the primary focus of the *Opportunity Thinktank* would be on the early stages of the design thinking process that prepared students to better understand and frame problems for which they would be generating solutions. The next section provides an overview of each module.

The Opportunity Thinktank

The *Opportunity Thinktank* consists of seven modules that can be used as a mini-course or stand-alone sessions to help engineering students prepare for the ideation process. It is important to emphasize that these modules focus on the less exciting, research preparation aspects of problem solving. This part of the process takes effort and does not have the immediate payoff, or satisfaction, of coming up with an idea. This often overlooked area of problem solving, however, is critical for developing effective solutions to market problems. We use the "deep dive" metaphor taken from an ABC Nightline video showcasing IDEO and their design thinking process.

Module 1: Discovering the Entrepreneurial Mindset

This is the first of seven modules in the *Opportunity Thinktank* that is designed to provide the foundation, preparing students for refining problem statements, enhancing idea generation, and improving the quality of ideas for engineering design projects. This modules establishes a firm understanding of the "entrepreneurial mindset;" that focuses on stimulating curiosity and making connections and identifying opportunity gaps; all with the objective of creating value for the client. This concept is important as many students do not envision themselves as entrepreneurs, thus making these concepts are irrelevant and potential restricting their ideation abilities. This thinking is diametrically opposed to the role of an engineer, which is to design solutions to problems. That is what entrepreneurs do, and engineering students can benefit from this mindset. In fact, everyone needs to think about becoming an entrepreneur.

The module 1 lesson plan incorporates a case study while introducing several specific entrepreneurial skills that students can later apply to an ongoing project (Figure 1). The mindset characteristics sought in the module are to instill a sense of "Brimming with Curiosity", "Courting Serendipity" and "Cultivating Randomness" [2]. The module begins with an overview of the entrepreneurial mindset followed by lessons on specific skills including client pain points, the use of the 5 whys [3] and the P.O.V. mad-lib [4]. Following the presentation of these techniques a clip from the television show *SharkTank* is shown and students practice the demonstrated techniques using the *SharkTank* case study as an example. The specific case study shown in the module is the "BZ box" episode [5]. This is an exercise in seeing how point of view truly changes the problem statement. At the end of the in-class session student teams are given current newspapers to search for potential project ideas. Their individual homework assignment is to produce a list of 12 "bugs." These "bugs" must come from the scanned newspapers or by interviewing non-students for potential opportunities. This is done to eliminate redundant ideas solely centered on the college lifestyle.

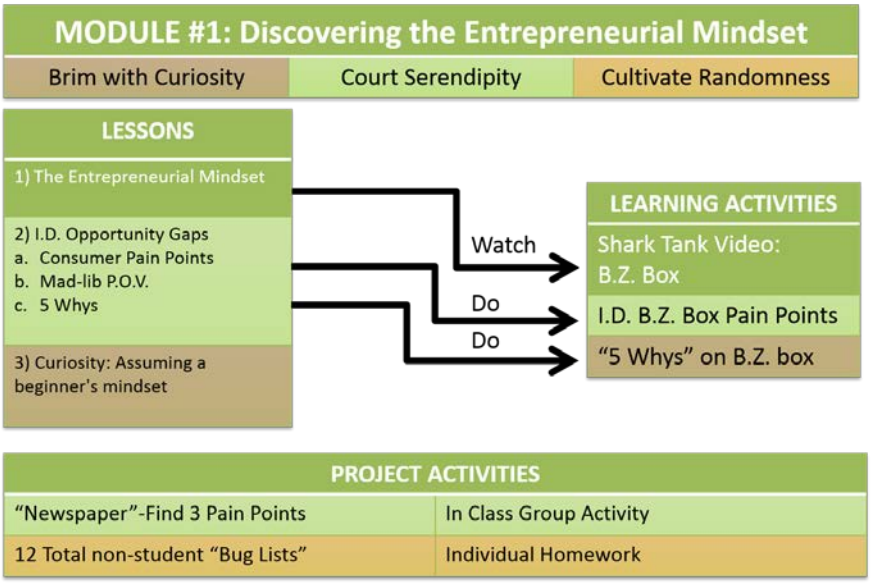

Figure 1: Schematic overview of the module one lesson plan. The banner at the top emphases the main mindset characteristics meant to be conveyed in the module. The lessons and specific skills then map to an ongoing case study of the Shark Tank, B.Z. box. Follow on project activities are shown below.

Sparkol brand video-scribing software was used to create a video for students to review at a later time. The video highlights the main takeaways from module one including the entrepreneurial mindset, client pain points, the 5-whys technique and the P.O.V mad-lib technique. Snapshots of the video are seen in Figure 2. The video can be given to students to view for homework or can be shown at the start of the next class period as a refresher on the key lessons from module one.

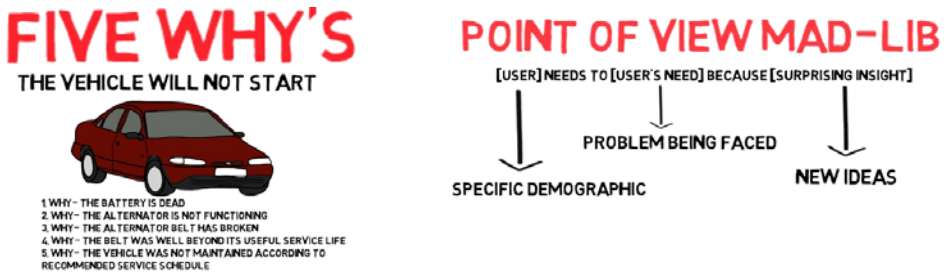

Figure 2: Schematics shown to students in teaching the 5 whys and point of view Mad-lib techniques. These figures are shown in a slide show followed by a video.

Module 1 continues into a second class meeting where student teams share, combine, eliminate and refine their potential bugs. Students first share all potential opportunities, pain points or "bugs" and write them on post-it notes. Teams with four students should generate at least 48 potential ideas, which are then stuck to a wall (Figure 3). Students then combine and group like

ideas and vote for top bugs using stickers. Students are given 12 stickers to be used to vote for their favorite bugs. Students are instructed that they can spread their voting stickers as they see fit, multiple stickers can be put on one good bug for example (Figure 3). All post-it note bugs are then removed except for the 12 with the most votes. Students then perform a 5-whys analysis on each of the remaining 12 "bugs." All students on the team then vote again for the top four bugs, with each student having four votes to be cast in the same manner as the prior vote. Teams must then complete an out of class assignment to frame their bugs by performing the P.O.V. mad-lib exercise on the remaining four "bugs". At this point the module 2 lesson plan may begin.

Figure 3: Students voting on the "bug" lists. First students write "bugs" or opportunities on post it notes and then students vote on "bugs" they'd like to pursue further by voting with stickers.

Module 2: Discovering the Entrepreneurial Mindset: Information Integration

The second module in the *Opportunity Thinktank* focuses on understanding the importance of doing research. Module two examines the core content of "Integrating information from many sources to gain insight." This module focuses on training one new skill set, using the Phoenix Checklist. It should also be noted that student teams are told that they can add new opportunity ideas or "pivot" to related opportunities as they make new discoveries through the process. The process is meant to facilitate new opportunity generation and not be burdensome or stifling to the creative process in any way.

Module 2 begins with a reiteration of the premise of "Integrating information from many sources to gain insight" and it is noted we can do this at both the large and small scales. It should be noted that KEEN has refined their conceptualization of the entrepreneurial mindset to focus on making connections, which the process of conducting research and integrating information allows students to do. Two brainteasers are used to introduce the Phoenix checklist [6]. The first brain teaser should be an optical illusion. Any number of optical illusions can be shown, the McGurk effect is particularly effective if ample time is available in the class period [7]. The main point to be conveyed is that things are not as they always seem, stressing the importance of thorough research. The next brain teaser should involve a memory test. The memory test can involve asking students to memorize a certain number of digits or any similar memory test. The main point to convey is that we can only remember a certain amount of information. This memorization exercise should emphasize the importance of checklists in guiding the process.

The Phoenix checklist is then introduced with a history of its creation by the C.I.A. Students are given a Phoenix checklist blue print (Figure 4) and begin filling in the template for the remaining four "bugs" during the class period. This part of the process is completed as an out-of-class assignment due the following class period. Teams also submit a memo summarizing the main facts gathered from the process. A Sparkol wrap-up video on module two is given to students to view for homework.

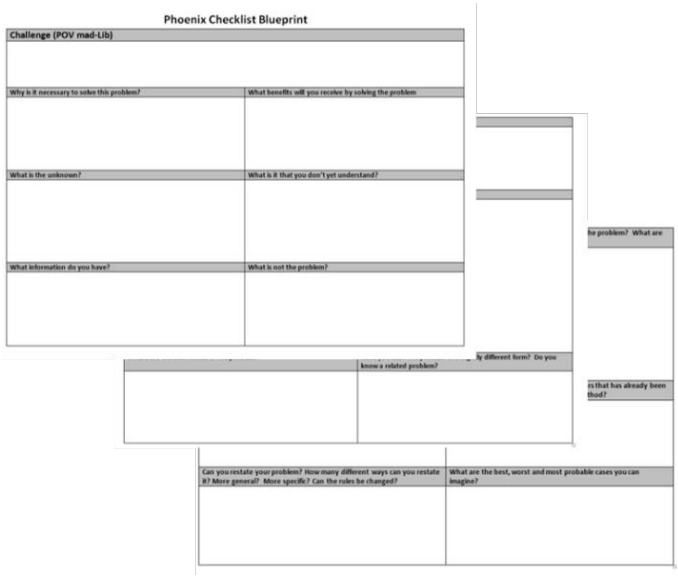

Figure 4: Phoenix checklist blueprint. These blank forms are given to student teams to facilitate research on the remaining four "bugs".

Module 3: Wading into Shallow Waters: Researching Trends

Module three establishes a starting point for collecting information from secondary sources to help with the process of making connections and opportunity identification. The importance of looking at information from both small and large scales is again stressed. This module is specifically designed to target the large scale which can be gathered from secondary sources. Prior to moving forward with the lesson students participate in a think-pair-share active collaborative learning (ACL) activity [8] in reviewing the results of the Phoenix checklist from module two. The lesson continues with an overview of secondary information sources including web based research, government sources, syndicated sources and library databases. It is stressed that in order to perform quality ideation and to make worthy decisions on which opportunity to pursue students must "stock the shelves" or collect as much information about each opportunity as possible. Four major questions that must be asked about each opportunity while conducting secondary research are presented, which are: on each of the remaining opportunities. The questions are:

1. Who is my end user/customer with the problem?
2. What are the current solutions for their problem?
3. What is the current state of technology for solving this problem?
4. What trends affect the user and their problem?

All of these questions must be asked for each of the remaining opportunities.

Students are shown two sources to get at the first question, the U.S. government census website (www.cencus.gov) and the market segmentation service "Prizm" from the Nielsen company [9]. Both sites are toured by the instructor while students watch. For the Prizm web site the instructor may ask for a student's hometown zip code and the particular market segments in the town are read. If time allows and computers are available students can research their own hometown market segmentation at this time. In order to answer question two students are directed to use Google.Finance, the U.S. patent and Trademark Office (USPTO) website, and the syndicated database from Marketresearch.com among other sources. For question three Google.Patent and the USPTO patent search functions are presented.

In order to address trends affecting users the "Trend Hunter" website is emphasized [10]. A video from Trend Hunter presenting the top trends of the year is shown, run-time approximately 5 minutes. Students are instructed to gather as much information from these sources to answer the four secondary research questions. A homework assignment is given to collect secondary information on each of the four remaining "bugs" and present the information in a written memo. Students are also presented with a simple decision matrix to assist them in choosing the most promising opportunity (Figure 5). This matrix can be modified to include additional, appropriate evaluation criteria or assign criterion weights. The decision matrix is then added to the homework memo assignment along with a rank ordering of the top three opportunities. After the

memo is submitted the instructor, along with the team decides on one “bug” to pursue for the remainder of the project. Again, “pivoting” is encouraged.

Evaluative Criteria	Bug 1	Bug 2	Bug 3	Bug 4
Societal Importance	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5
General Interest	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5
Market Need	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5
# of current solutions	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5
Solution Benefit	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5
Ability to create a solution	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5	1-2-3-4-5

Figure 5: A simple decision matrix shown to students to facilitate the decision making process. Based on the results of the decision matrix students are sked to rank order the remaining “bugs”.

Module 4: Diving in Head First: Observing Behaviors

This module gets to the core of the IDEO concept with the introduction of observational and ethnographic skills to understand the client pain point in the context in which it occurs. It is essential that the instructor and team decide on a single “bug” to pursue at this stage due to the increased time required to complete the required activities in the remaining modules.

The topics are introduced through a series of videos available from Stanford Univeristy’s eCorner [11]. Of note are the videos of David Kelley, Tom Kelley and Jessica Mah which directly address the need for observational study. The camera study technique is also described in this module [4]. Following the videos tips for conducting observational research are given including:

1. Set the scene
2. Observe physical space
3. Observe the people
4. Observe group interactions
5. Observe non-verbal behaviors
6. Just the facts
7. Record with your hands and tools
8. Zero in on the unexpected

A worksheet is provided to help students record their observations during the research (Figure 6). Before setting out to perform observational research on the team project students are given a

practice example. This is done by showing a video of people performing a task. One example is a video found on YouTube observing people doing laundry at a public laundry facility. Other videos can be used as well for this practical example. Students use the observational research worksheet while they watch the video and then share what they learn in an ACL think-pair-share format. For the out-of-class assignment students are required to conduct observational research on the "bug" they are now pursuing. This assignment is given in conjunction with the next module, Module 5: Interviewing for Empathy, so that student teams have ample time to collect the necessary information.

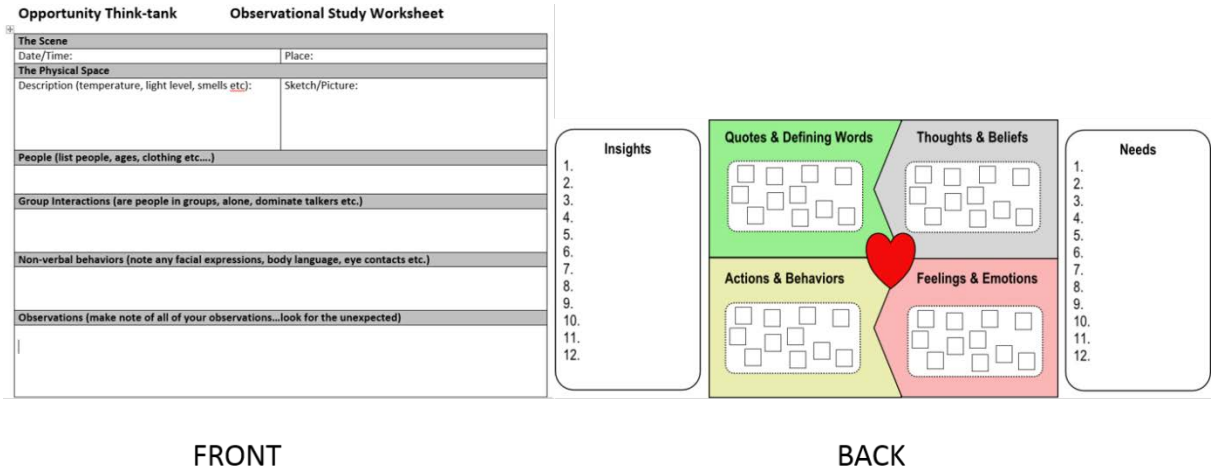

Figure 6: Observational research worksheet provided to students to facilitate observational research. The back of the form is adopted from Stanford's d-school bootcamp bootleg [4].

Module 5: Diving Deeper: Interviewing for Empathy

Starting with the second module, students are exposed to a process of collecting information to develop a firm foundation for the ideation process. Each module, from two to five, focuses on different techniques for information collection and organization. Module 2 began with organizing existing information the students may have from past experience or study in areas related to a specific bug. This is followed with Module 3 that focused on formal secondary research using a variety of on- and off-line published sources.

Module 4 begins the process of primary data collection using basic observational research methods. In this fifth module students learn about interviewing techniques to further their understanding of the challenge. The final goal of Modules 2 through 5 is for students to collect a variety of different types of information that they can use to better understand the identified bug.

An interview may look like a simple conversation to the casual observer, but interviews are a conversation with a purpose. Most students have very little understanding of exactly what an interview is, or how to conduct one. The interview process must follow a structured format and be administered in an efficient and effective manner. Students must know that a client's time is valuable, to them, and this time must be used in the most effective manner to generate useful information. That is a key thought. The information collected in the interview must be useful, otherwise it is wasted time spent on what may be a nice conversation but providing little help in guiding students to a better understanding of the bug.

The interview process begins with brainstorming questions. Students individually generate questions they feel are related to their specific bug drawing upon the information the team collected in their secondary and observational research. They then meet with their team (Think-Share) and collate all their questions, removing those that are redundant. At that point, the team reviews each question, discussing what type of information is collected and if that information will be helpful in better understanding the bug. Guidelines are provided for question structure, such as do not have questions with more than ten words; or, make sure a question is not "double barrelled" (asking for more than one answer in a single question). It is important to remember that the end result of the *Opportunity Thinktank* is a properly framed problem that will help guide the solution ideation process. This review process will refine questions for clarity and understanding, as well as remove any interesting, but unnecessary questions.

As the title of Module 5 indicates, this is a "deeper dive" into understanding the challenge, which is achieved by engaging in an interactive conversation with the client. Further, students need to gain an "empathetic" understanding of the client's pain point experience. They can only gain so much empathy from reading and observing, they need to vicariously "walk a mile in her shoes," so to speak.

The result of this process is the creation of an interview guide that can be used by all students in the team. This is important for standardizing the data collection process and generating more consistent and valid information. At this point in the module, students are provided guidelines on how to administer the interview (see Figures 7 and 8). Students are split into pairs and engage in a mock interview as practice.

The interview begins with the student introducing themselves and the project to establish rapport with the client. The interview then progresses from relatively simple, general questions to more detailed, specific questions. The early questions in the interview should help to establish rapport and not be perceived as threatening by the client. Throughout the interview process students should be probing client answers to questions and encouraging examples and stories. Stories are an excellent way to develop some level of empathetic understanding of the client pain point. At the end of the interview the student thanks the client for their time and addresses any questions.

Ask why. Even when you think you know the answer, ask people why they do or say things. The answers will sometimes surprise you. A conversation started from one question should go on as long as it needs to.

Never say "usually" when asking a question. Instead, ask about a specific instance or occurrence, such as "tell me about the last time you _____"

Encourage stories. Whether or not the stories people tell are true, they reveal how they think about the world. Ask questions that get people telling stories.

Look for inconsistencies. Sometimes what people say and what they do are different. These inconsistencies often hide interesting insights.

Pay attention to nonverbal cues. Be aware of body language and emotions.

Don't be afraid of silence. Interviewers often feel the need to ask another question when there is a pause. If you allow for silence, a person can reflect on what they've just said and may reveal something deeper.

Don't suggest answers to your questions. Even if they pause before answering, don't help them by suggesting an answer. This can unintentionally get people to say things that agree with your expectations.

Ask questions neutrally. "What do you think about buying gifts for your spouse?" is a better question than "Don't you think shopping is great?" because the first question doesn't imply that there is a right answer.

Don't ask binary questions. Binary questions can be answered in a word; you want to host a conversation built upon stories.

Only ask one question at a time, one person at a time. Resist the urge to ambush your user.

Make sure you're prepared to capture. Always interview in pairs. If this is not possible, you should use a voice recorder—it is impossible to engage a user and take detailed notes at the same time.

Figure 7: Directions on how to interview, adopted from[11].

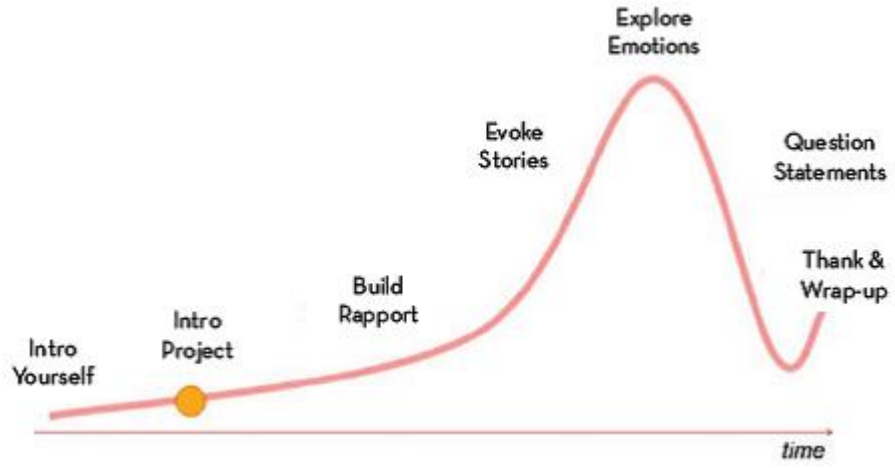

Figure 8: The interview process, adopted from [11].

Module 6: Emptying the Net: Unpacking and Synthesizing Data

At this point the students should be swimming in data, and keeping with our diving metaphor it is time to "empty the net" and examine the collected information from the team research activities. Figuratively, and in some instances, literally, the information is poured onto a table and the team searches for patterns that will help them better understand their client's pain point.

Module 6 begins with the four questions to guide information collection posed in Module 3:

1. Who is my end user/customer with the problem?
2. What are the current solutions for their problem?
3. What is the current state of technology for solving the problem?
4. What trends affect the user and their problem?

Each of these questions is investigated using different techniques designed for examining the data collected earlier in the *Thinktank*. It is here that students will unpack and synthesize the information they found through secondary, observation and interview research.

Since pain points reflect frustrations that people have, we start with the first question to gain a better understanding and empathize with the client. Using whiteboards or flipcharts, teams can begin with a Journey Map [11]. A journey map helps students understand the overall experience a client has with a particular frustration. It starts using a process perspective, beginning with the first point at which the client realizes that they have a frustration, and then adds the subsequent steps taken to resolve the problem with a current solution. It is expected that the current solution (if there is one) is inadequate, leading to a state of sub-equilibrium. The information required for creating a Journey Map can be found in secondary sources, abstracted from observational data, or by asking the client to talk about the pain point journey as part of the interview process. It is here that student should seek to develop empathy for client's experience.

After sketching out the process, students next construct Empathy Maps [11]. This technique provides understanding of a variety of different client characteristics for whom they are going to design a solution. Empathy Maps are divided into four quadrants (see Figure 9). Armed with a stack of Post-it notes, students record different pieces of information on a single sheet and classify them into one of four quadrants: Think, Feel, Say, Do. As can be seen in Figure 9, *Think* reflects client thoughts and beliefs, *Feel* their feelings and emotions, *Say* their quotes or defining words, and *Do* their actions and behaviors. Using Post-it notes makes it easy to move information from one quadrant to another as the team reviews the information.

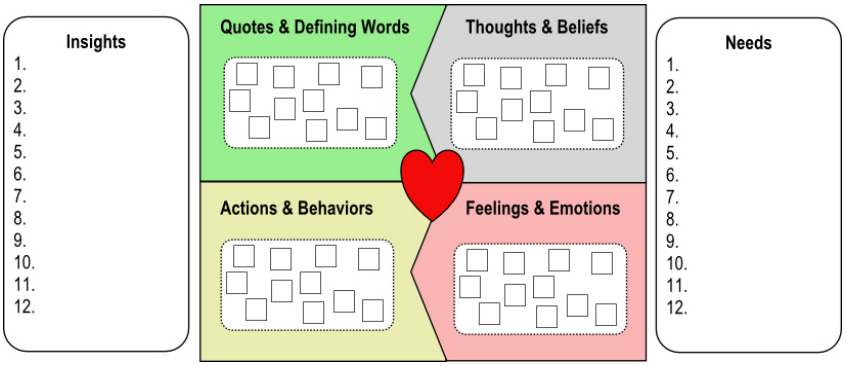

Figure 9: Empathy Map, adopted from [4].

It is very important that the students complete their empathy maps on a whiteboard, wall or flip chart. This makes it much easier for the team to step back and observe patterns in the information. As patterns emerge, the notes can be re-arranged to make better sense of client and their pain point. Two important outputs from this analysis are the identification of Needs and Insights [11]. Needs are considered to be necessities, be they emotional, psychological or physiological. Insights may be considered an AHA! moment, where students learn something about their client that they did not know and gain a deeper understanding of the pain point. These insights will be important for framing the problem and designing solutions.

The list of needs can be further explored using a Why-How Ladder [11] (see Figure 10). This technique, similar to the 5 Whys presented in Module 1, provides a structured process to more deeply explore the needs of the customer. This process drills down to root causes of pain points, providing added insight when designing solutions.

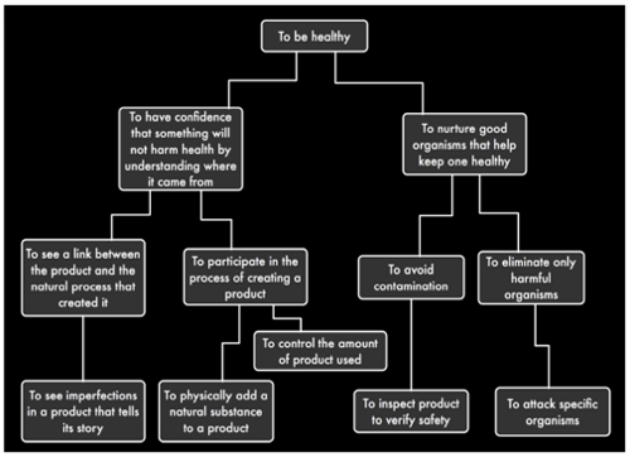

Figure 10: Why-How Ladder, adopted from [11]

After completing the first two synthesis activities the team is now ready to share and create stories. This activity begins with each team member sharing a story they collected from a client they observed or interviewed. The sharing of stories makes the client tangible and real. Other team members are encouraged to ask questions, probing deeper into each story. Once all team members have told their story, the team creates a single story based on all the information collected. This story conveys the pain point experience the client is experiencing in a particular situation. The act of creating a story helps the team better understand and empathize with their client. Teams can have individual members write stories and combine them into a single story, or work on the story in a team collaboration.

The second and third questions focused on current solutions to the pain point and the state of technology. A good technique to organize information is a 2x2 Matrix. This technique is relatively simple and helps to identify market patterns and open spaces of opportunities. For the second question, teams start by looking at all of the current solutions and classifying them on

two dimensions. For example, a set of current pain point solutions may be organized by cost (high versus low) and difficulty (easy versus hard). Using the whiteboard and Post-its, teams plot the solutions looking for interesting patterns that identify spaces of opportunity. The same process can be used for the third question when assessing the current state of technology. It is also possible to apply the Journey Map with minor changes when looking at technology. This adapted map would look at the evolution of technology up to its current state.

The last question focuses on consumer trends, which were organized in tabular form as part of the activity for Module 3. The team can use similar 2x2 matrices to classify different trends and help to prioritize them in terms of importance or concern.

Module 7: Framing the Problem and Preparing for Ideation

Teams now have collected and synthesized the critical information they need to frame the problem, the last step before engaging in solution ideation. All teams should have a Journey Map, an Empathy Map, a story that reflects the client's experience and persona, a list of needs and insights, and deeper understanding of the situation than when they started.

The process starts with the initial Point-of-View Madlib created in Module 1. This should be an iterative process that begins with each team member constructing their own POV Madlib, then sharing it with the rest of the team. Individual team member madlibs are then combined into a single problem frame. Teams can further investigate their POV using a Critical Reading Checklist [11] (see Figure 11). This activity helps to focus the POV and ensure that it reflects the insight gained during the research phase and is meaningful. The process has the team discuss four primary questions, after which the POV will likely be revised to enhance its focus and relevance.

Once the problem has been framed, teams can use another technique to examine the problem from different perspectives, the Reframing Matrix [12] (see Figure 12). The original conception of this matrix is slightly different from the one shown in Figure 12, which used the perspective labels of product, planning, potential and people. This analysis can use any perspectives that the team would like to explore before engaging in ideation. Looking at a problem from different perspectives helps shed light on issues the team may not have thought about, and identify potential constraints that will need to be taken into consideration when evaluation potential pain point solutions.

1. **What is the Point?**
    a. What is your team's angle?
    b. What is your team's framework in stating a POV?
    c. Is it user-centered, need-based and insightful?
2. **Who says?**
    a. How valid is your team's POV?
    b. Is your position supported by findings from users?
    c. Is it a distillation of the findings?
    d. Is this applicable outside of one colorful interview?

3. **What's new?**
    a. What is the value-add of your POV?
    b. Have you articulated your findings in a new way?
    c. Are they placed in the context of a user?
    d. If you POV doesn't feel new, can you be more specific?

4. **Who cares?**
    a. How is your POV significant?
    b. Is your excited ?
    c. Is this work worth doing? If not, why?
    d. Can you reframe/rephrase to improve your POV?

Figure 11: Critical Reading Checklist, adopted from [11]

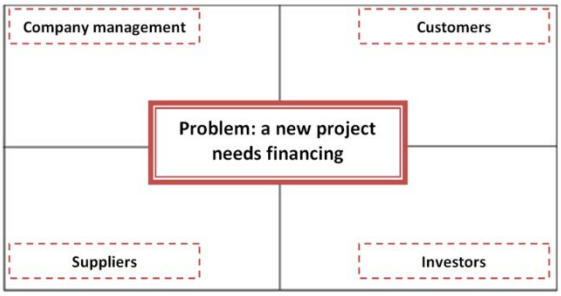

Figure 12: Critical Reading Checklist, adopted from [12]

At this point teams should have a well-defined and focused POV, with all team member clearly understanding the customer's pain point and the different factors that must be considered when designing solutions.

Assessment

All seven modules of the *Opportunity Thinktank* were administered to a combined group of students from a first year engineering course and a first year business course. Teams were formulated in each section and then combined with a typical structure of 3 engineering students and 2 business students. The student teams were tasked with creating a "smart-design project". This project details are more fully explained in a companion paper titled, "Innovation to Entrepreneurship in the First Year Engineering Experience." Other sections (six) of the engineering course were also given smart-design projects however only one section was given all seven modules of the *Opportunity Thinktank* outlined here. Two sections were given modules one and two of the *Thinktank*. The other three sections simply asked the teams to come up with a list of "bugs" and vote on them as a team, without performing any of the module activities. The main intent is to compare the outcomes of the section with the *Opportunity Thinktank* modules to those without and determine if there are any statistically significant improvements in project quality, entrepreneurial merit and/or overall level of entrepreneurial awareness.

Evaluation of project quality and entrepreneurial merit will be completed via surveys administered to independent judges at the end of the semester, while evaluation of

entrepreneurial awareness was done via comparison of “pre” and “post” surveys given to the students themselves. Table 4 shows a list of the questions in these surveys, all of which were answered by circling an integer between 0 (low) and 4 (high). The pre- and post-surveys were anonymous.

Table 1: Pre/Post Survey Questionnaire

Please rate your current level of knowledge/ability regarding...	
Q1	*identifying an opportunity.*
Q2	*investigating a Market.*
Q3	*creating a preliminary business model.*
Q4	*examining technical feasibility, customer value, societal benefits and economic viability.*
Q5	*customer engagement.*
Q6	*assessing policy and regulatory issues.*
Q7	*determining design requirements.*
Q8	*performing technical design.*
Q9	*analyzing design solutions.*
Q10	*creating models and prototypes.*
Q11	*validating designs.*
Q12	*communicating engineering solutions in economic terms.*
Q13	*communicating engineering solutions in terms of societal benefits.*
Q14	*validating market interest.*
Q15	*developing partnerships and building a team.*
Q16	*identifying supply chains and distribution methods.*
Q17	*protecting intellectual property.*

The overall results from the pre-survey and post-surveys are shown in Figures 13 and 14, respectively. These are shown along with their standard deviations (error bars). The orange columns show the responses from the sections which did not perform the advanced modules for problem formulation, whereas the blue columns show the responses from those sections which did.

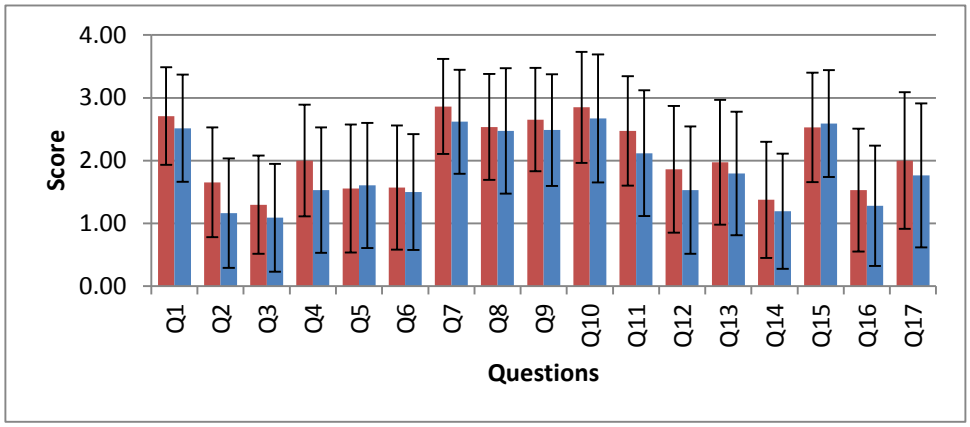

Figure 13: Pre-Survey Results. The orange columns represent the mean value of

responses of students in the standard sections. The blue columns represent the mean response values for students in the group that was exposed to the extra opportunity identification modules. Error bars represent standard deviation.

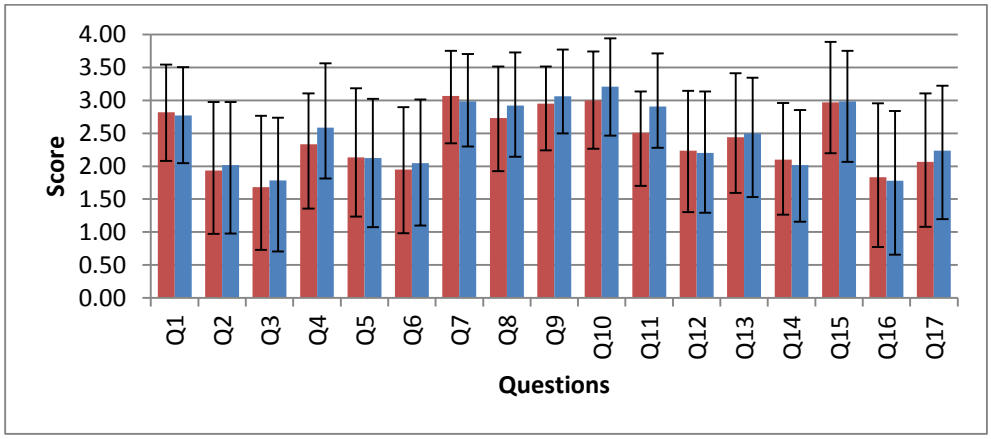

Figure 14: Post-Survey Results. As in the Pre-survey data, orange columns represent the mean value responses of students in the standard sections and blue columns represent the mean response values for students in sections exposed to the extra entrepreneurial modules. Error bars represent standard deviation.

Figure 15 shows the net gain from pre- to post-surveys. It can be seen from this figure that while all sections saw net gains across all questions, the sections in the control group (that is, those which underwent the advanced modules for problem formulation) showed consistently higher gains in most questions. It is particularly reassuring that some of the most pronounced contrasts can be seen in Q2, Q4, Q10 and Q11, which are perhaps the 4 questions most relevant to the advanced modules.

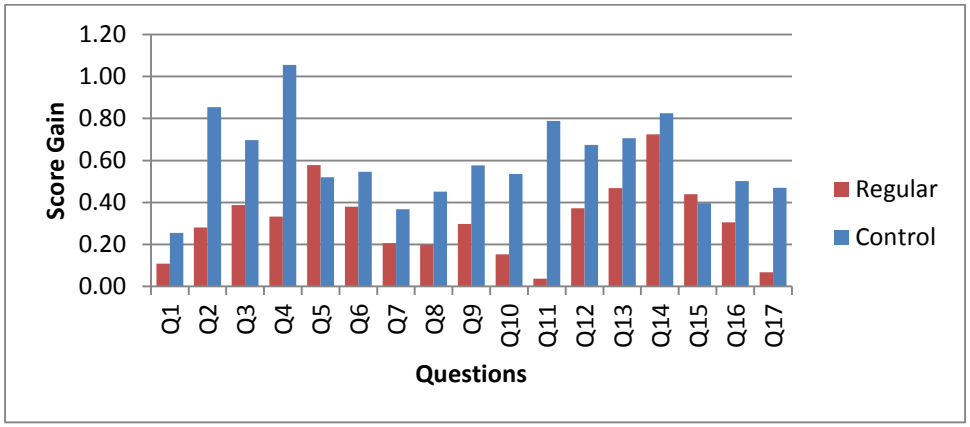

Figure 15: Net Gain Comparisons. These data represent the net gains between the pre- and post- surveys. The orange bars represent the gains made by students in the standard sections while the blue bars represent the gains made by students in the sections which were exposed to the opportunity identification modules.

Conclusion

The *Opportunity Thinktank* brings together and introduces undergraduate engineering students to critical knowledge in entrepreneurship, marketing and research methods they may not be exposed to in the standard engineering currciulum. Student self-reporting assessment indicates that students who took part in the Opportunity Thinktank gained a greater confidence in their ability/knowledge in the following areas (when compared to a control group not exposed to the modules):

- Investigating a Market
- Examining technical feasibility, customer value, societal benefits and economic viability
- Creating models and prototypes
- Validating designs

References

[1] KEEN Engineering Unleashed: Why KEEN? KEENzine. http://www.kffdn.org/files/keenzine-2-framework.pdf accessed March 5, 2015.

[2] Hoffman, Reid and Ben Casnocha, "5 Tips for Generating Breakout Opportunities," *Entreprenuer*, (June 19, 2012), accessed May 23, 2014 at http://www.entrepreneur.com/article/223716.

[3] Serrat, O., "The Five Whys Technique", Knowledge Solutions, Asian Development Bank, Feb 2009.

[4] *The Bootcamp Bootleg*, D. School, Hasso Plattner Institute of Design, 2014.

[5] "BZ Box", Shark Tank, Episode 527, ABC, May 16, 2014, television.

[6] Michalko, Michael. Thinkertoys: A handbook of creative thinking techniques, 2nd Edition. New York, NY: Ten Speed Press (2006).

[7] "Is Seeing Beliving?", Horizons, BBC Two, May 18, 2010, television.

[8] Gerhart, A., "Campus-wide Course Modification Program to Implement Active & Collaborative Learning and Problem-based Learning to Address the Entrepreneurial Mindset", 2013 ASEE Annual Conference and Exposition, June 23-26, Atlanta, GA.

[9] The Nielsen Company (2015), *My Best Segments*, [online], available: http://www.claritas.com/MyBestSegments/Default.jsp

[10] Trend Hunter, inc. (2015), *Trend Hunter: Find Better Ideas Faster*, [online], available: www.trendhunter.com.

[11] Stanford University (2015), *ecorner: Stanford University's Entrepreneuship Corner*, [online], available: http://ecorner.stanford.edu/.

[12] Morgan, Michael. *Creating Workforce Innovation: Turning Individual Creativity into Organizational Innovation.* Sydney: Allen and Unwin (1993)