Experiential and Interactive Learning in Engineering Innovation and Entrepreneurship Program

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Abstract

The paper will highlight a successful faculty-led program that was run in San Jose, California for the past three years to promote experiential and interactive learning in the entrepreneurial surrounding. Students took two courses for credits: (i) Introduction to Customer-Driven Technical Innovation and (ii) Introduction to Product prototyping at Silicon Valley. During the program, students experienced the technology-driven world of Silicon Valley. Silicon Valley is the innovators' and entrepreneurs' dream world and is ground zero for customer-driven technology evaluation, innovation, invention, and prototyping. It is also an ideal location for inspiring interactive and non-traditional college learning experiences. Students spent time visiting start-ups and large corporations and worked on a project where they advanced, through multiple iterations of the design cycle, an idea to a testable prototype. In this paper, we will show innovative experiential learning approaches and their outcomes. This includes samples of student demonstrations and projects, and several learning activities used as part of the experiential and entrepreneurial education. We will also present prototypical course requirements, such as customer survey, market analysis, proposals for projects, project reports, and designing and *building* prototypes. This work will be beneficial to other educators to style their experiential learning approaches.

Introduction

Northeastern University (NU) Global Experience Office (GEO)[1] set up several special programs available to all students to provide intellectually challenging and culturally enriching opportunities inside and outside the US to promote experiential learning. Such experiences enhance students' on-campus studies and prepare them to become effective leaders in an increasingly global community. In "study abroad", participants spend one summer/semester at a foreign institute to take classes for credits and to interact with local students and academic communities. In "global co-op", the many US and international companies and organizations working with NU offer 6-month co-op programs where students are exposed to diverse cultures and have opportunities to address today's global challenges. In "dialogue of civilization" (DOC)[2], students are offered opportunities to take their NU courses led by NU- faculty in the US or an overseas location to promote experiential learning. This paper focuses on the "dialogue of civilization" held in Silicon Valley. Silicon Valley's innovation history, startup culture, business language, work lifestyle, multicultural food, industry innovation, museums, natural environment, and many other features differ from the rest of the USA. During their time in Silicon Valley, students will develop teamwork experience, interactive experience, and a good understanding of the domain outside the classroom.

The title of my Dialogue of Civilization program is: "Technical Innovation and Product Prototyping". We have offered this program over the past three years, in 2018 and 2019, it was on-site and in 2020 it was virtual due to the pandemic. The objective of this program is to reform education by moving away from the boundaries of traditional classroom-based methods to project-based[3-7], concept-based, team-based[8-11], market-based, customer-driven[12-13], skill- and knowledge-integrated approaches using the real-world situation, in our case - the "Silicon Valley".

Silicon Valley also represents an international environment, and a good mixture of startup and established companies. Students across the entire University are eligible to participate in this program. This program is particularly appealing to those who are highly motivated and naturally curious about how things work, and those who are interested in technical innovation, technology transfer, startup companies, product prototyping, and the culture of entrepreneurship in the region. As part of this program, we offered two courses. One is Introduction to Customer-Driven Technical Innovation at Silicon Valley (course number is GE2010), the other is Introduction to Product Prototyping at Silicon Valley (course number is GE2030). Incorporating new innovative techniques with traditional teaching is an interesting idea and is in practice at several institutions. How these activities impact learning varies and is an open question for all time.

Program Overview

Program description
The program is looking to have students experience the technology-driven world of Silicon Valley. They will spend time understanding new technologies, what drives them and how to be prepared to be entrepreneurial and to use technology and the internet in creative ways. Beyond the design of devices and problem-solving, they also get to see market forces, customer-driven needs, and rapid design in a new light.

The first course (GE2010) is focused on analyzing common shortcomings of early technology startups and helps to understand successful innovation design and commercialization strategy. The key to success is correctly identifying, understanding, and developing a good relationship with the customer. Particular emphasis is made on understanding real market needs, "Jobs-To-Be-Done" and how to gather relevant information to make an educated decision early on. The real market need was by doing customer survey at various level, which includes end-users, clients, and designers. This course will benefit students of all disciplines. The course will demonstrate, through a series of practical projects, how to assess your capabilities, find and communicate with your end-users and clients and correspondingly develop your product to fit their needs. Topics covered include an overview of technology transfer, innovation models, customer discovery, lean startup, open innovation, and its implication, interview and analytical techniques, competitive intelligence and competitive advantage, value proposition, elevator pitch, and other types of a business plan, presentation skills, and techniques.

The second course (GE2030) seeks to develop in-depth knowledge and experience in prototyping by focusing on engineering processes and instrumentation that are used in different industries. Overall learning objectives are listed below.

Learning outcomes

- Develop understanding of both invention and commercialization processes, their commonalities and differences for engineering projects.
- Develop an understanding of the market needs, customers and end user.
- Develop an understanding of basic principles of product design and value creation.
- Develop skills and understanding of the process of customer discovery, interactions and relationship as relevant for business development.
- Experience the culture of innovation and creative design.
- Analyze the various companies and models for elements of success and transfer.
- Acquire familiarity with various models of innovation and innovation strategy
- Learn interview and presentation skills
- Develop critical thinking and acquire skills for competitive intelligence
- state the prototyping cycle and apply it to iteratively create products
- learn about user and technical testing methods for prototypes
- advance through multiple iterations of the design cycle from an idea to testable prototype
- understand human-centered design approaches to product design
- use digital fabrication techniques to quickly create prototypes

Eligibility

Any Northeastern University student with the required GPA is eligible to participate in the program. Students from various disciplines participate in the program which includes engineering majors, business majors, various science majors, and other fields.

Courses

We offer two courses as part of this program:

GE2010: Introduction to Customer-Driven Technical Innovation at Silicon Valley (see Appendix 1), and GE2030: Introduction to Product Prototyping at Silicon Valley (see Appendix 2).

GE2010 Course Description

Here we study the role of engineering innovation in addressing customer needs in early start-ups and the need to conceive successful innovative engineering design as part of a commercialization strategy. Emphasizes understanding how engineering innovation can meet real technical market needs and how to gather the necessary, relevant technical information early in the innovation process to produce a successful engineering design. Uses a series of engineering design projects to demonstrate how students can assess the technical capabilities of the start-up in producing an innovative design, how to communicate with customers in an iterative engineering design process, and how to correspondingly design and innovate to meet customer technical requirements.

GE2030 Course Description

This course seeks to develop in-depth knowledge and experience in prototyping by focusing on engineering processes and instrumentation that are used in different industries. Studies the prototyping cycle, from initial process flow and sketching to prototype development to testing and analysis, with an emphasis on iteration. Analyzes how different kinds of engineering prototypes can address design and user-interface needs vs. functional needs, such as looks-like and works-

like prototypes. Offers students an opportunity to obtain operating knowledge of methods including 3D printing, SolidWorks, off-the-shelf hardware-software interfaces, simulation, embedded systems, product testing, prototype analysis, and prototype iteration.

Onsite Activities

During our stay, we visited about ten companies, invited over ten guest speakers, and participated in several non-company activities and social events. As part of the course work, we had about eight student presentations and four prototyping activities. We also had several team-building fun activities such as social dinners, amusement park day, beach day, game time, and more. These activities enhanced the interactive and experiential learning experience.

The dialogue offered two courses on customer-driven technical innovation and product prototyping, which included activities, such as, visits to several established and start-up companies, visits to Tech Innovation and Company Museums, listening to numerous guest seminars given by managers at the Silicon Valley companies, customer interviews, and social events. Stu-dents were required to present a case study on Silicon Valley companies, their failures and success stories, proposals for projects based on customer survey and designing, building and presenting prototypes, and to write project reports with a business plan. Learning about Silicon Valley start-up and large corporate culture provides valuable opportunities for education, research, and professional careers for Northeastern University students.

In the next section, we have listed various experiences the students were exposed to during the program including some event photos from institutional, interactive, and innovation, teamwork, and some social activities.

Institutional Experience
Multiple company and institutional visits, few samples are listed below.

Figure 1a: Intel visit

Figure 1b: Tesla visit

Figure 1c: Google visit

Figure 1d: NU Silicon Valley campus

Figure 1e: VMware visit

Interactive Experience
Interactions with Leaders, Innovators and Entrepreneurs

Figure 2a: Interaction with a CEO

Figure 2b: VMware Discussion

Figure 2c: Interaction with AMD team

Figure 2d: Interaction with a Google Engineer

Innovation Experience

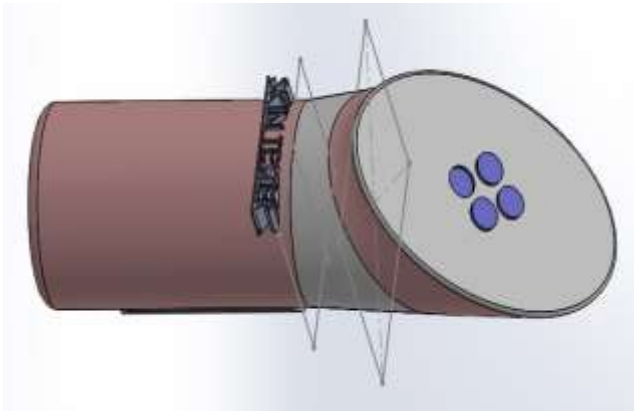New Ideas, New Products, New Business Plan via Innovation

Figure 3a: Skin Tester - Inexpensive method to diagnose the pore sizes, acidity, hydration, and oil levels of an individual's skin.
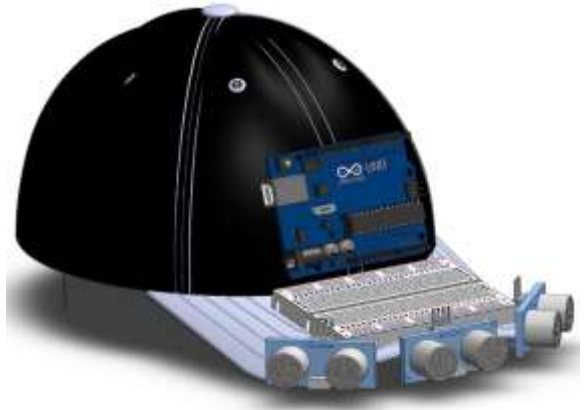

Figure 3b: NaviCAP - How to improve the daily life of the blind in terms of navigation, social interactions, safety, and daily living.

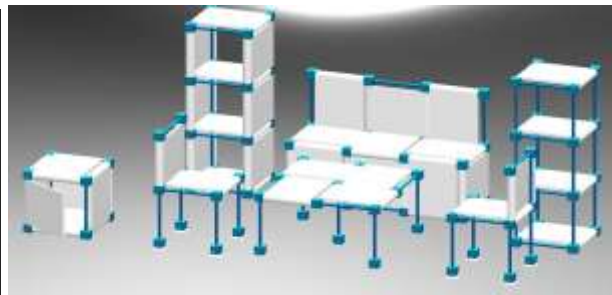Figure 3c: Quick Spot - Looking for parking space.

Figure 3d: Regalo Project - Highly portable modular furniture that can be customized, assembled and disassembled with the structural integrity of LEGO,

Team Work Experience

Alone we can do so little; together we can do so much. - Helen Keller

Figure 4: The figures show various team discussion in small groups, and makerspace use.

Social

Another integral part of the program was several social activities for cultural and interactive experience.

Figure 5a: Santa Cruz Beach visit

Figure 5b: Great American Park visit

Figure 5c: Alcatraz visit

Figure 5d: Bicycle ride at Intel

Discussion

We offered this program for the past three years, in 2018 and 2019, it was on-site and in 2020 it was virtual due to the pandemic. On average, during onsite programs years, we had about ten company visits, five non-company activities, ten social events, student presentations, and about four projects/prototype activities, and over ten guest speaker participation.

As part of the course activities during the past three cycles, we have generated about ten innovative product ideas and prototypes for products. A few samples are shown in figures 3a to 3d. In addition, we have done several interactive assignments and demonstrations. Since this paper's main focus is the general overview of the program, we are not able to give more details about all the activities. A sample customer survey and business plan are shown in appendices 3 and 4 for one of the products. For the customer survey, students had reached several groups using various techniques, such as online surveys, phone surveys, and in-person interviews. Together, this approach develops their skills to deal with market needs in the real world setup. We have done similar work for all the innovation projects. Noticeably, this was accomplished within five weeks, which itself is a very challenging task for the students.

The pictures show some selected social activities, visits to various companies, project diagrams, teamwork, and more. This indeed gives some samples for others who want to try something similar. The assessment was conducted by the GEO at the end of the activity period which is not presented in this paper since this paper is about programs and activities. The student feedback was positive and encouraging for other students.

Conclusion

The Outcomes of these activities are Experiential and Interactive Learning Experience on Innovation, Prototyping, and Entrepreneurship. The skills learned from these activities were invaluable and ideal for experiential and interactive learning. It also involves interacting with customers, market analysis, company visits, teamwork, network, new product idea, prototyping

activities, writing reports, and presenting to an audience. The overall experience goes beyond just classroom experience. We hope that the concept from the educational model proposed in this paper will serve as a milestone, and help future educators to recognize that experiential learning is necessary to educate students in all engineering disciplines. The skills learned from this program were invaluable experiences within the engineering and entrepreneurship program.

Acknowledgement

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Appendix 1: GE2010 Sample Syllabus (five weeks)

:Week	Topics	Assignments/Activities
Week 1	Engineering and Entrepreneurship Intro Why we are here – career paths Entrepreneurship Failure and Success What's missing – changing perspectives? Technology development life cycle Ideas without intent Valley of death Successes and Failures Assignment 1 presentation and Discussion	**A1: SV Companies and Products** Consumers, Market size, product Improvements. Presentation/Discussion/Report Due date
Week 2	Innovation vs invention From idea to the product Technology transfer Commercialization Licensing, sales, and acquisition Service model of commercialization Defining market and market needs Marketing, sales Market analysis Market size Technology application and unsolved needs Assignment 2 presentation and Discussion	**A2: Failed and Successful Innovations** Presentation/ Discussion/Report Due date
Week 3	End users, customers, client, and targets Talking to your customer Interview techniques, and analysis Innovation strategy Models of innovation (history and reality) Open Innovation and Disruptive Innovation Creative Destruction Disruptive Innovation Assignment 3 presentation and Discussion	**A3: Customer Needs and Solutions** Whose needs, End user's or clients, what is the jobs that needs to be done there? Presentation/ Discussion/Report Due date
Week 4	Value proposition and business plan Solving your customer needs Customer interviews as a tool for value proposition development Types of business plan Investor presentation Competition, Competitive intelligence and Competitive advantage Direct and indirect competitors Solving the need vs technical details	**A4: Questionnaire and Interviews** Who are your customers, market consideration, talking to customers, interviews, analysis, feedbacks or clients, what is missing in the market? Presentation/ Discussion/Report Due date

	Working with your competition Competitive advantage Assignment 4 presentation and Discussion	

Week 5	Formula of success and Overview
	    Crossing the valley of death with
	    knowledge and skills
	    Know your end user
	    Work with your customer
	    Choose the right strategy
	Final presentation and report
		A5: Silicon Valley Company Feedback:
		Experiential learning outcome based on these activities.
		Report Only
		Due date
		
		FP: Presentation/Report
		Presentation and Report Due

**Appendix 2: GE2030 Sample Syllabus (five weeks)**

Week	Topics	Assignments/Activities
Week 1	Course Intro Design Philosophy & Process Paper Prototyping Personas Specifications Types of Prototypes	**P1: Graphics Assignment:** Assignments Due date **P2: Paper prototype: Silicon Valley Product** Demo/Presentation Due date
Week 2	CAD 3D Printing Laser Cutting	**P3: Product Prototype: Advancement** Presentation/Report Due date **P4: Reverse Engineering: Silicon Valley product** Presentation/Report Due date
Week 3	Design Analysis Humans Hardware Debugging Hardware. Final Project Intro	**P5: Prototype: Design/Build** Demo/Presentation/Report Due date **P6: Rapid Prototype: Sensors Based** Demo/Presentation/Report Due date
Week 4	Ideation Value Sensitive Design Manufacturing Implementation	Building Final Project prototype
Week 5	Final Testing Final Presentations Final Documentation	**Final Project: New Product** Demo and Presentation due

Appendix 3: Customer Survey

Sample customer survey question and response on the Skin Tester product shown in Figure 3a is provided below.

What gender do you identify as?
54 responses

- Female
- Male
- Prefer not to say
- I turtle 🐢

27.8%
70.4%
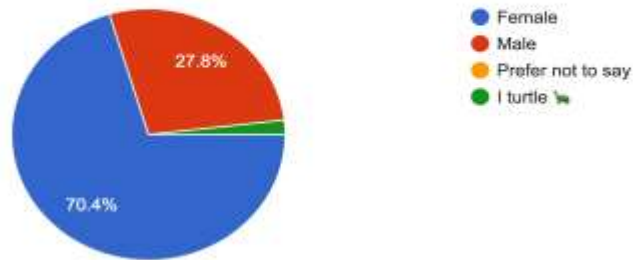
How much do you spend on average each month on skincare products?
54 responses

- $0-$15
- $15-$30
- $31-$45
- $46-$60
- $61-$100
- $100+

13% 14.8%
22.2%
40.7%
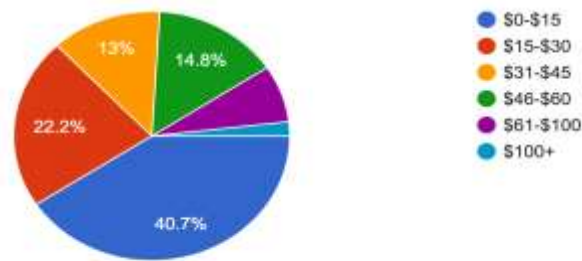
Do you think you need or want a professional to diagnose your skin to provide you with accurate analysis?
54 responses

- Need, yes!
- Want, yes!
- Not really

29.6%
46.3%
24.1%
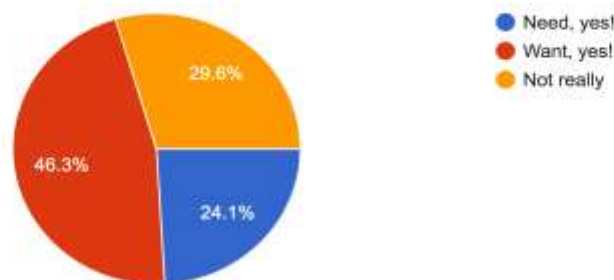
What are your top 3 skin concerns you are trying to address currently? (select no more than 3)

54 responses

Concern	Count
Hydration	31 (57.4%)
Aging	16 (29.6%)
Dark spots	14 (25.9%)
Oily skin (large pores)	19 (35.2%)
Breaking out/Skin irritation	26 (48.1%)
White/black heads	22 (40.7%)
	1 (1.9%)
Overall freshness of skin	1 (1.9%)
no concerns	1 (1.9%)
Pigmentations	1 (1.9%)
Dry skin	1 (1.9%)
open pores	1 (1.9%)

Would you buy an at-home non-invasive skin tester that tells you more about your skin characteristics includ...d on your individual skin properties?

54 responses

- Yes
- No
- Maybe

13%
24.1%
63%

What if the skin tester also gave you customized product deals (from your fav brands!) based on your results, w...that increase your motivation to buy?

54 responses

- Yes
- No
- Maybe

9.3%
20.4%
70.4%

Appendix 4: Sample Business Plan for the Skin Tester product shown in Figure 3a is provided below.

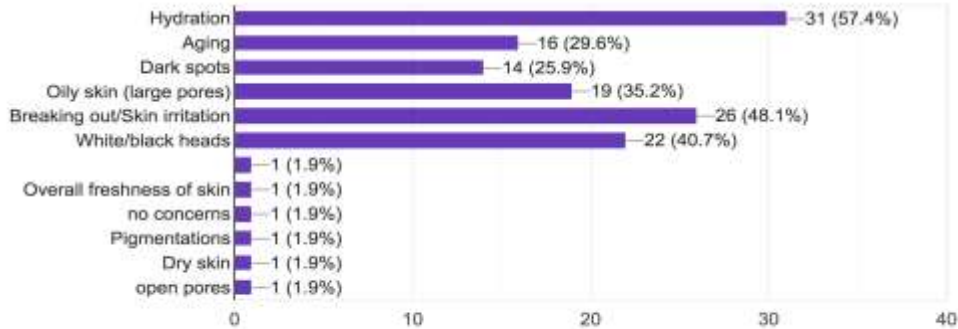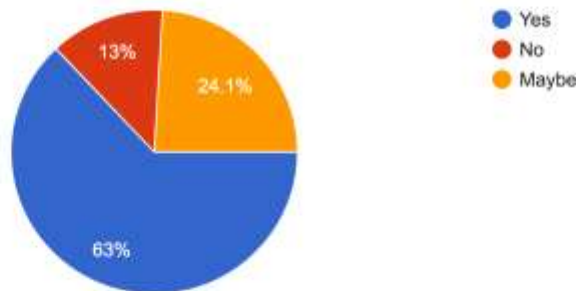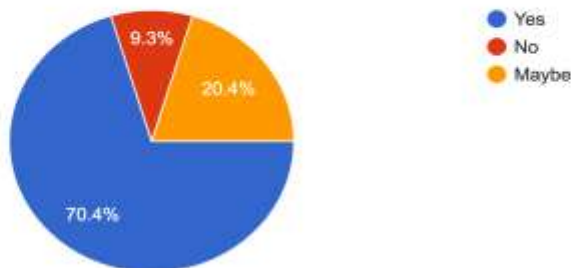| Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
• Dermatologist • Skin care brands • Influencers • Manufacturing Partner	• Network/ Platform development • Relationship development • Marketing **Key Resources** • AI model • Data collection and analysis	• Personalized product recommendations	• Direct & prioritized customer relationship • Integrated in B-model **Channels** • Direct: Retail (Sephora, Nordstrom, Barney's, Online store)	Primarily, • Asian Women • Age 20-40 yrs

Cost Structure	Revenue Streams
• Value based Pricing	• Product sale (skin tester) • Data distribution to skincare brands • In-house products