Lead User Experiential Learning - 'Learn-by-Doing' Pathway to Financial Self-Sufficiency

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Michael is a patent holder of US and international patents and has carried the importance of product development into his involvements with the non-profit organizations Center for Leadership Development (Indianapolis, IN) and Academy of Business Leadership (Rosemead, CA) while helping to facilitate the success of each group's mission to 'foster the advancement of minority youth in central Indiana as future professional, business, and community leaders' and develop youth that will become 'the agents of change needed to make a difference in their communities, schools, and world.'. Michael is the 2008 Center for Leadership Development Achievement in Science and Technical Disciplines Award Recipient.

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Abstract

The employment needs of the STEM workforce have been steadily increasing over the past decade. Many opportunities exist for properly trained students to contribute in the STEM areas. The Bureau of Labor Statistics states that 100% of STEM occupations will see an increase in jobs in the next decade. As a result, retention of students in engineering, technology, and technical schools is important to future productivity (GDP) across all sectors. A model is proposed where Kolb Experiential Learning Cycle fundamentals in conjunction with development of student 'lead user' abilities would have a significant effect on academic metrics associated with student outcomes such as student retention as well as professional metrics in the areas of placement and career development. The proposed model would supply the impetus for a Value Mitosis Initiative (VMI) at any college/university where the learning model would lead to increased equity and GDP in the university/college community and affiliated communities. Proper development of the lead user experiential learning model should cause improvement in academic and professional metrics associated with accreditation such as student outcomes and institutional support while providing the foundation for financial self-sufficiency within the school and in communities associated with the school.

This same lead user idea development process can be implemented within any community, taking conceptual ideas of talented people from within that community whose abilities may be underestimated, undervalued, and marginalized and developing their ideas into products, thereby providing employment opportunities in addition to equity for that given community. The Corporation for Economic Development launched The Racial Wealth Divide Initiative in September 2013 in New Orleans and Miami and has expanded into Baltimore and Chicago in 2017. Their mission is focused on United States wealth inequality statistics.

In 2013, United States wealth inequality statistics (reported in Table 1) illustrate the extent to which race currently affects finances.

Table 1. US Wealth Inequality Statistics

Metric	Black	Latino	White	Overall
Average Household Wealth	$85K	$98K	$656K	$509K
Median Household Wealth	$1700	$2000	$117K	$64K

The goal of the Racial Wealth Divide Initiative is to have a significant effect on these wealth inequality statistics in specific cities. Lead user experiential learning is one tool that could ultimately have a significant effect on this statistic.

Lead user experiential learning could serve as a valuable tool not only in academic settings but also within any community outside academia. These communities could be rural, socio-economically disadvantaged, or clinical groups (e.g. physicians, nurses, physical therapists, etc.) to name a few. The resulting value is both tangible (new product development, equity, et cetera)

and intangible (e.g., creating opportunities for people to contribute, generating excitement through application of STEM fundamentals, and so on).

Background

The employment needs of the STEM workforce have been steadily increasing over the past decade. Many opportunities exist for students that have been properly trained to contribute in the STEM areas. The Bureau of Labor Statistics estimates that healthcare occupations and industries will have the fastest employment growth between 2014 and 2024.[1] Occupations in STEM fields are projected to increase by 9 million jobs equaling a 13 percent growth during the approximate same decade. There is no other area or sector where job growth is estimated to be higher during this time frame.[2]

It is imperative that US STEM education provides sufficient numbers of students that are properly prepared to meet this increased need. In order to ensure that this happens, students must be incented to enter STEM education areas and remain in them. Understanding what makes students interested and generates excitement within the STEM areas is an important factor towards increasing student interest, success, and retention. The benefit is both academic and economic where increased productivity in STEM areas can fuel growth in business sectors. Increasing the magnitude of successful students in the STEM areas is a factor that can have a significant effect on this productivity. The question is 'How best can STEM education provide the greatest probability of success for the greatest magnitude of students?' Part of the answer comes from attracting and retaining many more women and underrepresented minority students to STEM. Studies show that students from these populations are likely to be motivated by a desire to make life better[3]. This aligns very well with the Lead User Experiential Model.

Previous studies have demonstrated that engineering students have differing learning styles. According to Kolb each student's learning style is divided into four distinct learning modes; accommodator, diverger, converger, and assimilator.[4] These learning styles are summarized as:[4,5,6]

Converger: person who is best at determining how to apply ideas to resolve a problem; often choosing the engineering profession

Diverger: someone with a strong imagination who can generate ideas, with a focus on people and relationships; frequently found in management

Assimilator: describes those who observe, reflect, and effectively develop theory to logically explain conditions and situations; common trait for scientists and mathematicians

Accommodator: person who thrives on action and/or risk-taking, following an iterative approach to issues rather than reflecting first; gravitating to positions such as sales.

Although every engineering student demonstrates each of these learning modes to some degree, "researchers have found that the percentages of engineering students categorized by learning style listed in rank order from most to least are convergers and assimilators (about equal percentages) first, accommodators second, and divergers last".[6,7,8,9] A system that encompasses all of these learning modes would have the highest probability of setting a given student up for success. One such system would accomplish this goal via a cross-functional interaction of engineering and business students, or by linking engineering students with lead-users from another community. If a student has a positive experience with someone with a different but complementary learning style early in his/her career, the engineering student has a higher likelihood of future career success, where working with other types of learners is expected. This applies to their engineering academic career as well as other fields where engineers earn graduate degrees and have successful careers such as law, medicine, finance, and operations management.

Project centered learning has historically been a cornerstone of engineering education. In these projects, the instructor/faculty member provides the information and data for the project, and the students (usually working in groups) work to complete the problem given to them. Students often gain confidence from these projects and provide statements such as "made me more excited about the major", "made me want to take more classes to learn all that I still don't know", "what I had been waiting for", "what we are here for", and "one of the few times where you actually apply, hands on, the theory that you learn all through school."[10] These 'capstone' projects usually take place during the student's senior year.

In the conventional senior-level 'capstone' project-centered learning project, the student has no role in the problem's conceptual development. The problem along with all of its parameters is given to the student, and the student's sole responsibility is generating the solution.

Conversely, freshman 'Introduction to Engineering' courses take a broader approach to engineering where typical course objectives are:

1. "Providing an encouraging, interactive learning environment."
2. "Developing an understanding of the profession."
3. "Developing skills for team-based problem solving."

One implementation of the lead user experiential learning model modifies this standard approach to freshman 'Introduction to Engineering' courses such that the underclass student is considering real issues, is able to make immediate contributions using their freshman level skill sets, and engages their desire to be creative in a way that encompasses all of the learning modes that have been identified by Kolb. The same lead user experiential approach could also provide an interactive cross-functional learning opportunity for the underclass management student. The management student can gain through the experience of articulating market and customer needs while working alongside an engineering student that is able to convert these needs to engineering metrics, product specifications, and ultimately a prototype design. These experiences would be beneficial to both students as well as providing a platform for a quality project to be developed. Another implementation of the lead user experiential learning model pairs the capstone student team with prescreened lead users to work together to systematically develop community ideas into products. (Some of this prescreening can be accomplished by the freshman project teams).

The inventive process of the proposed model has a foundation in the fundamental process observed in successful inventors. This process has seven steps:[11]

1. Observation of a need or difficulty.
2. Analysis of the need.
3. A survey of all available information.
4. A formulation of all objective solutions.
5. A critical analysis of these solutions.
6. The birth of a new idea.
7. Experimentation to test and refine the most promising solution.

As previously mentioned, the first step in the inventive process is 'observation of a need or difficulty' followed by 'analysis of the need'. These steps could also be referred to as 'market needs assessment' or 'opportunity focuses' in standard business plan terms.[12, 13] Usually the focus of a business plan is conversion and use of the 'market needs assessment' and 'opportunity focus' information to provide market potential information and financials to support the idea or concept. A focus on the conversion of business plan information to engineering metrics and initial prototype development using concept and design review fundamentals via providing an interactive learning experience would provide a successful learning model for engineering students.

In a standard business plan, the primary focus is identification of the total available market (TAM) and competitive advantage of the product being presented. The conventional first two steps in business plan development identification of a target market are:[14]

1) Identification and evaluation of a range of market options
2) Understanding the customer needs in your target market. This includes determining who the customer is and understanding the customer's core needs.

The conventional business plan process has been modified by Dr. Robert Cooper and is called the Stage- Gate® Product Innovation process[15] The steps in this process have demonstrated success in increasing the probability of a successful product getting to market as well as reducing the product lifecycle time. The Lead User Experiential Model adopts the Discovery Phase, Scoping, and Build Business Case steps from Dr. Cooper's process.

A key part of a successful lead user engineering curriculum will be harnessing the lead user abilities of the students in cooperation with targeted communities, thus engaging their creativity and innovation while also meeting the needs of students that learn via each of the distinct learning modes. Understanding the importance of harnessing the lead user abilities is important and can lead to the success of the 'value mitosis initiative' (VMI) where a single idea is used to increase knowledge and improve community socioeconomic status using the model of cellular mitosis.

VMI is a methodology based on the principles of basic cell physiology to improve socioeconomic status of any community. The measurable goal of this activity is an increase in GDP/capita. If VMI were to be initiated in a set of communities, the effect can be analyzed and observed via the measurement of selected educational and financial metrics. VMI's primary goal is to leverage the visible and latent talents within any community to improve that community's socioeconomic status. However, educational benefits exist as well. In this particular model, the community affected would be the university/college and the adjacent community.

Value Mitosis: Basic Cell Structure and Entrepreneurial Activity

All living organisms are made up of cells. Each cell can be divided into cytoplasm and nucleus. The cytoplasm contains all parts of the cell not present within the nucleus.[16] The resources of the cytoplasm allow the individual cell to live and become a source of growth. All cells with the exception of mature red blood cells possess a nucleus which determines the cells function and structure.[17] Most importantly, each cell is unique as a result of its nucleus and has the ability to replicate itself many times over without any external energy or stimulus through a process called cellular mitosis. Just as a living organism is made up of many types of cells, a successful organization can be made up of many different product ideas and the resources developed as a result of each individual idea's success.

Value mitosis (VM) modifies the concept of cellular mitosis by moving the activity from a physiological platform into the platform of a community. A community can be defined as a unified body of individuals. The body of individuals is not required to be located within a proximity to function as a community. Some examples of communities where value mitosis may take place include a group of individuals from a certain sector like physicians or engineers, a national non-profit organization like a community organization or church, or an educational entity, as shown in Figure 1.

The Lead User

Lead users are individuals who have product or service requirements that are ahead of the needs of the average consumer. In the VMI model, lead users provide the nucleus through which the community improves its socioeconomic status. Harnessing any community's lead user abilities is fundamental to the success of VMI. One way these abilities can be harnessed is through focus groups where new ideas are brainstormed. Many times, the lead user will create a novel product or process to meet customer need.[18] . A simple example of lead-user product development is the Hands-On Basketball™ (see Figure 2). The product was created by nine-year-old Christopher Haas to help teach his friends the proper technique for shooting a basketball. He developed the product by sticking his hands in poster paint and placing them in the correct positions on the basketball. The product was manufactured and sold by a company called Sportime. The financial benefits of that idea allowed Christopher to send both himself and his sister to college, as well as make donations to children's organizations, thereby providing the basis for a form of intellectual mitosis[19].

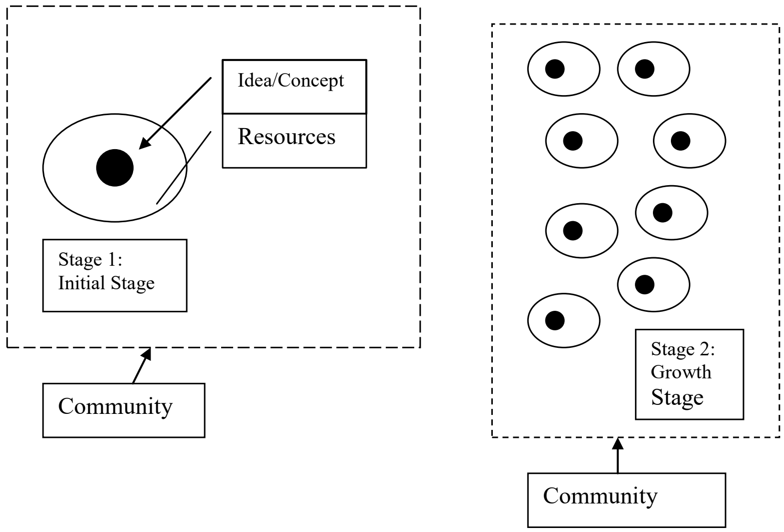

Figure 1. Value Mitosis: Process Diagram

Figure 2. Hands-On Basketball™

Proper use of lead user information and involvement has demonstrated a significant positive effect on both new product development speed and firm profitability[20] . Short new-product-development life cycles are not only associated with higher productivity and lower levels of inventory and working capital[21], but also with reducing the occurrence of value migration. "Value migration occurs when value leaves economically obsolete business designs and flows to new business designs that more effectively create utility for the customer and capture value for the producer"[22] . VMI provides a method to create these new business designs.

According to Luthje and Herstatt[23] , the lead user process consists of four distinctive steps:

(1) starting the lead user process,
(2) identifying the needs and trends,
(3) identifying the lead users, and
(4) creating the concept design.

A university or community college with introductory and capstone engineering design projects can establish the mechanisms needed to incorporate lead users and VMI into their courses. The unutilized lead-user potential present in any community has the potential to change the socioeconomic status of any community. The key is the development of the first cell within that community, which provides the structural basis for the growth and development of a living organism that will lead to community empowerment through increased ownership in the community. The lead user responsible for the success of the first cell will act as the “lead generator” or “lead innovator,” ensuring that resources are in place to support the development of additional cells.

The strongest characteristic of a lead-user concept is often its simplicity. Everyone has a unique perspective that can be channeled into valuable lead-user ideas. Some of the strongest lead user ideas in recent history have been developed by people under the age of 25[24]. Each of these ideas could be like the first cell in any community’s socioeconomic improvement. The fundamentals learned in STEM education provide this foundation. The earlier that a student realizes these fundamentals provide them an opportunity to contribute via experiential learning techniques, the more likely the student may be to continue through the rigors of the engineering curriculum. This can also be nurtured through arrangements such as the Purdue Foundry (Purdue University; West Lafayette, IN) or community-based maker spaces[25]. The model allows for focus on the inventive process and engaging students of all learning modes.

Research Approach

Our goal is to better understand the effects of this model of lead user experiential learning such that we can apply it earlier and more often in an engineering curriculum to improve student and community success metrics. We will leverage existing project-based curricula in senior engineering capstone courses, in which we have observed student engagement, retention, and adjacent community value as a result. These courses take ideas from lead users in the industrial community and provide students with an opportunity to develop these customer needs into engineering requirements that they use to develop prototype products. We will collect data on student retention and success as well as adjacent community benefit as a result of their participation in these courses. These metrics are detailed below.

Our goal is to develop the proposed model in an already functioning lead user experiential learning environment (i.e. senior capstone) to refine the application of the model and measurement of outcomes. Using the processes and data collected during this development, we will implement a similar model earlier in the curriculum, at the freshman and sophomore levels, and measure similar metrics of retention, success, and adjacent community benefit. Our hypothesis is that early and sustained application of this learning model in an engineering curriculum will lead to greater student success and improved benefit to the university and adjacent communities.

Metrics and Program Success

The metrics of success will be a hybrid of existing metrics and new metrics that may not currently exist. Some of these will be determined as a program is developed and optimized. For example, some of the current metrics that are used to measure the effectiveness of a STEM education program (e.g. The Puerto Rico Louis Stokes Alliance for Minority Participation [PR-LSAMP]) are:[26]

1) "Increase the number of students who enter a graduate degree program in a STEM field"
2) "Increase the number of students who complete a PhD program in a STEM field"
3) "Sustain the annual number of BS STEM graduates"
4) "Sustain and enhance the direct student support strategies that have proven successful to retain and motivate undergraduate STEM students to pursue graduate studies"
5) "Sustain the collaborative network between different STEM faculty from the different PR-LSAMP institutions for exchange and mentoring in the implementation of successful strategies to enhance the teaching and learning process"

Metrics very similar to these will be used to measure the success of VMI. Some additional metrics may include:

1) Improved retention in engineering programs.
2) Improved overall GPA in engineering programs.
3) Improvement in the Gross Domestic Product of the community.

After implementation of a lead user experimental learning model in underclass curricula, the same metrics will be measured for that cohort as they pass through the university. We hypothesize that these metrics will improve with earlier and more frequent exposure to the model. These metrics also provide a baseline to measure the effects of modifications and improvements to the model as it is developed year over year.

Results

Our initial results are qualitative in nature but serve as the impetus for a more quantitative assessment. Students in the Biomedical Engineering Department at California Polytechnic State University at San Luis Obispo (Cal Poly) express their excitement for their future careers after being subjected to this model in their senior design/capstone sequence. Although this occurs in their senior year, we rarely see any dropout from the program after completion of this sequence of courses. Engagement in core major courses and technical electives appears to be fueled by their gaps in technical knowledge while developing their product prototypes. Furthermore, we see increased interest in pursuing employment, graduate and professional school, and the founding of new ventures to further develop their prototypes into products and businesses.

Startups, clinicians, and well-established corporations also benefit from this model. We recruit early stage ideas and vague customer needs from these sources to provide the loose framework upon which students build their lead user experience. The result of which provides a tangible benefit to these organizations and individuals (in addition to a 'real world' problem from industry for the students). The distillation of fuzzy customer needs into refined engineering metrics along with the fabrication and validation of a functional prototype helps move a concept further down the product development pipeline, or conversely, provides an inexpensive and efficient way of determining that the business case for a product doesn't align with the engineering realities. Additionally, we observe that the individuals and companies involved often benefit from the generation of intellectual property results from these early stage design activities.

Discussion

One of the model objectives is to improve the quality of science, technology, engineering, and mathematics (STEM) education for all undergraduate students by making product development fundamentals a significant part of early engineering education. A key part of the initiative is focus on the tangible application of skill sets learned in STEM. Although STEM encompasses more than engineering, the initiative is built on a fundamental engineering principle. Engineers solve problems through accurate assessment of customer and/or market needs and provide their internal or external customer with a product, process, or service that alleviates the problem.

Additionally, undergraduate business schools generally provide students with fundamentals in the areas of accounting, finance, and marketing in addition to the management areas of consulting, entrepreneurship, and information technology management. Case studies provide students with excellent learning experiences via the business activities of others early in their undergraduate experience.

First and second year undergraduate business and engineering students often do not receive the opportunity to exercise applied learning. Harnessing of 'lead user' ideas of both underclass engineering and business students in a cross-functional activity could not only be valuable to the learning process for each group, but also provide a source of financial sufficiency for those students as well as other areas of the university/college community and adjacent communities.

One hypothesis is that a proper 'lead user' experiential model will have a significant positive effect on the success and interest level of students through demonstration of potential application of STEM and business fundamentals early in the engineering and business student's academic career. As a result, the student will be more likely to exert a greater effort in learning the fundamentals thus enhancing their probability of academic and career success in both STEM areas and business areas.

Metrics will be identified that will allow quantification and tracking of the initiative's progress and effectiveness. Some of these metrics already exist and additional metrics will be observed and developed to allow for monitoring academic and financial measures of the initiative effectiveness. It is believed that this initiative will have a significant effect on the overall number of STEM and business students as well as the retention rate of students. One goal of this initiative is the development of a system that not only has a significant effect on student academic and career success but also the Gross Domestic Product of the community.

Many universities already have programs in place where 'Learn By Doing' principles can be leveraged to assist students entering entrepreneurial endeavors. A few of these are:

- Cal Poly (San Luis Obispo, CA) – "The Cal Poly Center for Innovation and Entrepreneurship (CIE) helps students and community members acquire the tools, develop the skills, and cultivate the mindset of an entrepreneur so that they may create economic and social value throughout the world."[27]

- Purdue University (West Lafayette, IN) – The Burton D. Morgan Center for Entrepreneurship has a Certificate in Entrepreneurship and Innovation Program that "teaches students in all academic majors how to turn their innovative ideas into action."[28]
- Rutgers University (Piscataway, NJ)– Rutgers Business School has The Collaborative for Technology Entrepreneurship and Commercialization (CTEC). "CTEC's focus is on translating cutting-edge technology and scientific discoveries into new business opportunities as startup ventures or new lines of business."[29]
- UCLA (Los Angeles, CA) – "The Harold and Pauline Price Center for Entrepreneurship and Innovation is a recognized leader in entrepreneurial education and research at the UCLA Anderson School of Management. Working closely with its board of advisors, the Price Center fosters the study and practice of entrepreneurship and business innovation by providing the foundation on which creativity can flourish and individuals can succeed."[30]

These programs are only a few of the programs that already exist where experiential learning concepts can be leveraged to successfully create opportunities and have a positive socioeconomic effect on not only the academic communities, but any community associated with each entity.

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