AC 2010-55: DEVELOPING AN EXTENSION FOR ENGINEERING EDUCATION: TESTING THE ENTREPRENEURIAL SKILLS OF KEY PARTICIPANTS

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Developing an Extension for Engineering Education: Testing the Entrepreneurial Skills of Key Participants

Abstract

The development of an engineering education extension in high desert of California is testing the entrepreneurial skills of the key participants due to several factors exacerbated by the State's budget crisis. A unique approach to provide ABET accredited undergraduate engineering education for the residents and the industry of the Greater Antelope Valley and adjacent regions has evolved, out of the regional desire to train engineers locally, without a thorough understanding of customer needs. A realistic model for higher education suggested by Maguad has been adopted that views employers as the customer and students as the higher education product. Understanding who the customers are is the crucial first step, according to Drucker, in understanding customer needs.

Guided by Dewey's and Tyler's works on curriculum development, an exploratory mixed-methods study was initiated to identify customer needs. This was a sequential-explanatory study. The initial phase was quantitative and defined critical cases that informed the qualitative phase. The qualitative phase had two components. The first component was long interviews with senior managers or executives from organizations purposefully selected to participate based on the critical case identification from the first phase of the study. The second component was integration and synthesis of existing data and the findings derived from the interviews. The final result of the study was a force-field analysis that provided the basis for recommendations that will guide decision making relative to curriculum and program development designed specifically to address regional industry needs. This paper will discuss the research method, results, and the issues that the study revealed relative to industry needs as well as the structure and status of the program as it currently exists and the plans that have been derived from the recommendations that resulted from the study. This paper will also discuss recent events that are redefining the effort and the application of experience gained to entrepreneurial education in engineering.

Introduction

Traditionally, entrepreneurship in higher education has been associated with research-intensive efforts[1]. Entrepreneurship in higher education has also been linked with innovation and economic development exemplified by the Massachusetts route 128 corridor, the North Carolina Research Triangle, and the Silicon Valley in California[2]. More recently, entrepreneurship has been linked with efforts to create social value resulting in what is commonly referred to as *social entrepreneurship.* The key feature of social entrepreneurship is the focus of an entrepreneur on advancing a social mission over the creation of economic wealth[3]. Recent events relating to the longevity of an engineering extension development effort underway since 2004 have created a situation that is testing the entrepreneurial skills of key participants in an industry/education/government consortium.

The events that have beset the engineering extension are that the university that operates the extension has determined that the effort must be phased-out over a four semester period and terminated. The decision to close down the extension effort is multifaceted. The basic premise at the inception of the program in 2004 was that the effort would be provided without expense to the university main campus or to the college of engineering beyond reasonable faculty and staff time commitments. Basically, the decision to phase out was based on a lack of self-sustaining funding and insufficient enrollment revenues exacerbated by under-enrolled classes, aging telebroadcast equipment, and the fact that the effort was outside the university service area. The sustainability of the venture was further challenged by multiple changes in leadership at the Dean's level at the college of engineering and at the extension between 2004 and the summer of 2007. The recent economic downturn has severely impacted the university system, as well, creating an unprecedented response involving staff/faculty furloughs and a severe statewide enrollment reduction. The enrollment reduction requirement essentially eliminates enrollment revenue generation as an incentive to operate the extension.

The challenge faced, by the consortium of engaged partners within the region, is a second round of enterprise creation within the public university system. The enterprise requiring creation is the extension itself. This effort falls more appropriately within the realm of *social entrepreneurship*[1]. Social Entrepreneurship addresses the social gains that result from entrepreneurial activities involving colleges and universities. These socially oriented gains might include increases in community prosperity and quality of life that arise from university-spawned economic development. Additionally, academic (social) entrepreneurship has been linked with university partnerships with industries that in return produce jobs for graduates[4]. In the case of the engineering extension, the jobs are available. Locally trained engineers are preferred, by the region's industry, as being better retention investments than are graduates from outside the area. The need is to produce graduates to fill the available jobs[5].

Among the first tasks conducted by the Director of Engineering Programs, newly hired in the summer of 2007, was an industry needs assessment. The stimulus for this effort was the endeavor by a public university to establish a unique extension of its college of engineering in the high desert of California. The problem being addressed by this study was that there was a perceived general lack of affiliation with and information from industry related to the engineering program extension that the university was operating[1]. The purpose of the study was to obtain the information needed to understand the industry and community needs and support capabilities so that informed decision making and planning could occur[6]. Now, more than ever, the results of this study are being used to guide decision making and planning. The study results are useful in efforts to shift partner perceptions and paradigms in an effort to develop innovative solutions to the necessary development of a sustainable and regionally scalable[1] support plan that will enable operation of the extension by a new university. In this context, sustainability refers to the ability of the extension to maintain its functional existence and, scalability refers to the ability of the extension to,"… grow its resources, operations, and influence beyond the scope of origin"[7].

Successful enterprise creation will provide the faculty and staff with real world entrepreneurial experience and a case study for use in the engineering curriculum. A new enterprise affords the opportunity to infuse the entrepreneurial experiences and learning gained into the curriculum. According to Crawford, Broer, and Bastiaansen[8], Engineering students need to be better trained in entrepreneurship and innovation management, to expand their vision of career opportunities, to introduce non-technical skills needed and to enhance their performance in small, focused companies. For instance, engineers are expected to have a broader range of skills, a greater sense of teamwork, more eclectic interests, and an awareness of information from sources outside of their field of interest.

The Problem and the Purpose of the Assessment

The problem that this study addresses is that there is a lack of affiliation with and information from industry and the communities related to the public university engineering programs. The purpose of this study was to investigate industry and community needs for engineering education in the high desert in order to inform the university's planning and decision making.

Research Questions

Tyler's[9] seminal work in curriculum development provided the basis for developing the research questions for this exploratory study. The issues surrounding affiliation and the ability to set goals and accomplish informed decision making can best be accomplished within the framework of Tyler's 4 questions and Dewey's description of the fundamental sources of educational objectives as related by Tanner and Tanner[10]. The research questions for this study were[6]:

1. What is the demographic information provided by regional organizations that would support an engineering program at a State University remote location?
2. What are the available resources to support development of a regional learning center for engineering?
3. What curricular offerings in engineering should be delivered?
4. What are the marketing strategies and tools that may be effective in student recruitment?
5. How should the success of the regional learning center be assessed?

Theoretical Basis

This study is framed by Tyler's[9] seminal work on curriculum development. In his work Tyler poses four questions which are: (a) "What educational purposes should the school seek to attain?"[11]; (b) "How can learning experiences be selected which are likely to be useful in attaining these objectives?"[12] (c) "How can learning experiences be organized for effective instruction?"[13]; and (d) "How can the effectiveness of learning experiences be evaluated?"[14]. Answering the research questions has resulted in data that addresses Tyler's first and second question from the perspective of industry needs which have resulted in conclusions and recommendations that address his third and forth questions, which relate to the interventions and evaluation methods that are most appropriate. Bearing in mind Tyler's questions, this study was further framed by considering and adapting Dewey's description of the fundamental sources of educational objectives. These sources are the learners and program participants, the society/institutions/communities that are involved, and the content or skills to be acquired and subject matter knowledge available[9].

The needs assessment for these sources resulted in the ability to conduct a gap analysis that compared *what is* with *what should be*[9]. These sources are further characterized based on their reference to either the local undergraduate programs or to the graduate programs. This characterization results from the source of students entering the undergraduate and graduate programs. The local undergraduate program obtains students that have completed their lower division requirements at the local community college and other such institutions while the graduate programs obtain students who are working adults with an interest in continuing their educations.

Research Philosophy and Framework

The philosophical underpinning for this research was pragmatism since this study was intended to develop an understanding of a specific problem[15]. The problem, in this case, is the perceived lack of industry support and the complication, for the local program, presented by having another public university at the same site offering an overlapping curriculum. Pragmatism is a method of thinking that does not focus on the attainment of truth. It allows the researcher to focus on distinguishing between those hypotheses which are legitimate and those that are not[16]. A pragmatic approach to research design allows the researcher to focus on the problem of interest and it allows for maximization of the flexibility that the researcher has available to develop a research design employing mixed methods. "Thus, for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as to different forms of data collection and analysis in the mixed methods study"[17].

This research was exploratory in nature as no presumptive hypotheses were established regarding the nature of the stated problem[18]. The strategy selected to guide this research implementation was sequential and explanatory as described by Creswell[15]. Sequential – explanatory research is typically conducted in two phases. The first phase is the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The first phase (Phase I) quantitative data was analyzed and the results used in purposefully selecting participants for entry into the second phase (Phase II). Creswell and Clark[15] identify this methodology as the explanatory design –participant selection model. This study used two distinct methods for gathering qualitative data in the second phase. These two methods were conducted sequentially as well. The first method in this second phase was the targeted interviews directed at the purposefully selected participants. These interviews were used to refine and explain the general understanding obtained during Phase I of this study. The second method focused on extracting specific content from the interviews, integrated with field notes, to synthesize a view of what should be. A final analysis that evaluated the gap between what customer's desire and what is currently being provided was conducted to establish the need. This second method was identified as Phase III.

Another feature typical of sequential – explanatory research is that priority is typically, but not necessarily, placed on the first phase of research. The main issue with sequential – explanatory research is the time required to collect data. The data collection time requirement issue is also exacerbated when equal priority is given to both phases[18] as was the case for this study. Equal emphasis on both phases of sequential-explanatory research is consistent with the pragmatic worldview[18].

Sequential – explanatory research is well suited to research where it is desirable to use the results from the quantitative data analysis to identify participant characteristics for purposeful sampling in the qualitative phase. It is also well suited to research that is designed to use the quantitative data results to follow-up with groups[19]. This study was designed to take advantage of both survey questionnaire responses and one-on-one interviews. The pragmatic philosophical underpinning coupled with the exploratory, sequential – explanatory mixed method framework produced rich findings of greater utility in understanding the stated problem than would be the case using either quantitative or qualitative methods alone.

Industry Assessment Methodology

The focus of this study was the development of a regional learning center for engineering. The method used to understand the development requirements was to assess customer needs for undergraduate and graduate engineering programs offered locally in the high desert. The customers that were included in this study were the businesses; local, state and federal government agencies, in the region, that employ engineers and that are expert in understanding the region's industry.

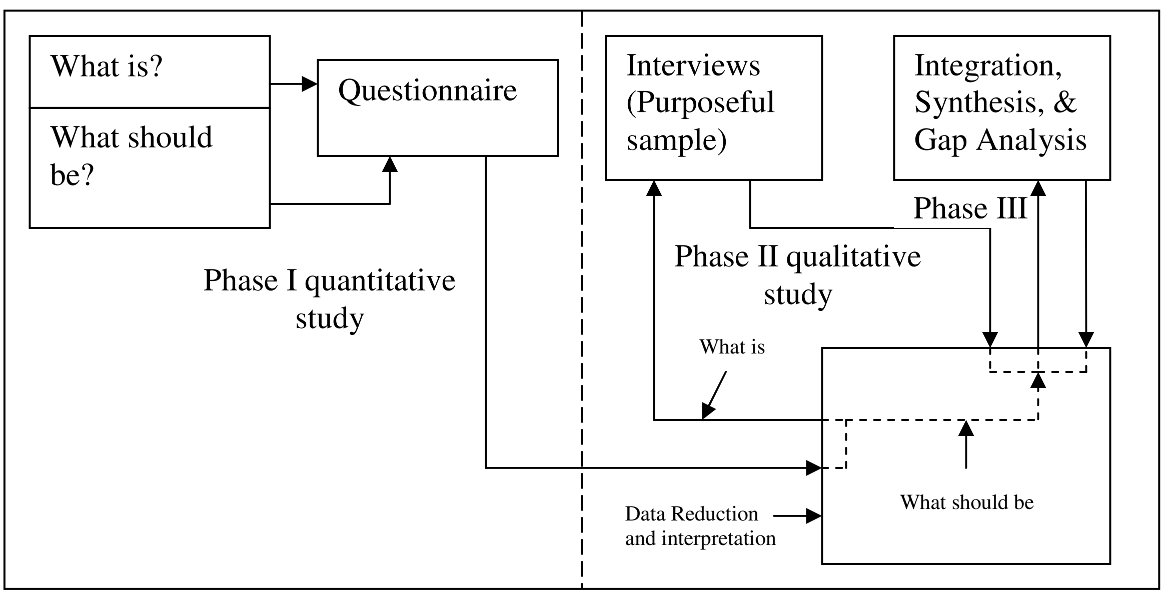

Figure 1: Mixed-method sequential-explanatory study design implementation.

The study employed mixed methods and consisted of three sequential phases (see Figure 1.). The three phases provided data to assess the customers' perceptions of *what is* in terms of the existing programs. Each phase informed the following phase of research activity thus allowing a degree of triangulation[17]. The first phase consisted of a 25 question cross-sectional survey questionnaire, directed at Human Resource Directors or senior managers, from industry and government organizations, designed to obtain applicable characteristic data and to assess current customer perceptions that relate to the stated problem. The questionnaire was evaluated by a panel of experts and a pilot study was conducted using a group of similar organizations outside of the region. The questionnaire was then administered using email invitations to participate via

Survey Monkey and by direct mail where specific appropriate email addresses could not be obtained. This phase was used to target specific organizations for the second phase where selected senior personnel were interviewed. Three critical cases were defined for the selection of interview subjects.

Critical Case A was defined as aerospace, professional, and other industrial organizations. Critical Case B were federal and state district directors of elected officials, Critical Case C was the Building Industry. Interview questions for this second phase were developed focused by the results of the survey data from the first phase, tailored for each Critical Case. The Phase III analysis of the Phase II interview content, the review of field notes (records that were collected by the participant researcher throughout the year), and minutes from appropriate meetings, such as advisory board meetings, were integrated to synthesize, through the use of force-field analyses, the view of *what should be* thus allowing use of a gap analyses that allowed conclusions to be drawn and recommendations to be developed.

Population Description

The population for this study consisted of the industry, the local, county, state, and federal government organizations that employ degreed engineers, in the Greater Antelope Valley of Southern California, that graduate from ABET accredited schools. The Greater Antelope Valley is a large triangular region in the high desert of California that, historically, has been home to flight test and aircraft manufacturing industry and government organizations. Recent reductions in government research and development expenditures, a government inspired migration of aerospace industry to regions in the United States that have a lower cost of living and consequently a lower labor rate, and the demographic changes in Los Angeles County that have resulted from the Antelope Valley's lower housing costs have diluted the traditional aerospace industry's dominant position in Antelope Valley communities. Therefore, this study is intended to consider the total population of engineering employers.

The sample population was initially developed for the quantitative phase of the study. The analysis units consisted of 171 industries and government organizations resident in the region that were identified by the researcher as being likely to employ engineers as defined by the population under study. The researcher is a 27 year veteran from the aerospace industry and has over 36 years of engineering and government service experience. To ease the burden of identification, companies and agencies listed in the region's various chambers of commerce provided the information for making the sample selection. The analysis results of the quantitative phase of the study informed the sample selections for the qualitative phase of the study. Interviews were conducted based on the availability of selected participants.

Data Analysis

For Phase I of the industry assessment there were 23 questions designed to obtain pertinent data on the survey questionnaire. Of the 23 questions, the responses for 16 questions were coded and loaded into an EXCEL spreadsheet to facilitate data sorting and descriptive statistical analysis. Data logs were also created to record responses for five of the questions that asked for multiple responses. The remaining two questions were write-in questions and these responses were recorded verbatim in the results for Research Question 4. Research Question 5 was not addressed by the survey questionnaire but was dealt with during the second phase of the study. The primary tool used was descriptive statistical analysis which allowed tabulations of percentages, bar charts that provide graphical data comparison, and descriptive statistical analysis using NCSS[20]. The tabulations record the percentages of responses for each of the various ranges offered as answer choices for participants. The questions that allowed multiple responses by participants were presented in the form of bar charts. Attitudinal questions were tabulated providing descriptive statistical analysis of means, standard deviations, standard error, confidence limits, and sample size.

Preparation for Phase II required a review of the data collected during Phase I. This review indicated that there existed two major customer segments of concern. The first was the general category that included aerospace, professional and other industrial organizations. This segment is dominated by aerospace and large firms which, for the purpose of this study, are those with over 100 employees. This segment was defined as Critical Case A. The district offices of elected officials were designated Critical Case B. The district offices of elected officials were selected to provide a broad view of the regional industrial perspective due to the unique visibility that legislative members maintain within their districts[21]. Critical Case C identified the second largest segment of organizations employing engineers which is the Building Industry.

Phase II of the assessment consisted of long interviews recorded and transcribed. Qualitative content analysis of the transcripts based on Strauss and Corbin's[22] grounded theory was conducted. Two coders were chosen. One was experienced. Both coders had trained in the protection of human subjects. Instructions were provided to each coder along with the themes for coding and were reviewed with each coder. Paraphrased and bundled transcripts were coded by the researcher on multiple occasions until the final themes had developed and intra-rater validity was achieved. Inter-rater agreement was similarly achieved through multiple coding passes until themes were matured and inter-coder agreement was reached on the matured themes. Theme maturation was accomplished by first coding with the experienced coder. Agreement was reached on the initial coding pass. Themes were then reviewed by the experienced coder and the researcher and revised were confusion had been observed. The coding was then mapped to the matured themes and agreement was reached on the mapping. Coding then proceeded with the inexperienced coder using the matured themes. Agreement was reached through an iterative process of coding and recording agreements. In the event of a coding impasse, consensus between the coders for the correct theme was developed. Eleven themes were identified and the relationship between the themes and the research questions is shown in the Table.

Table

Relationship of Themes Developed from Interviews to Research Questions

Theme	Research Question
1. Opportunities for cooperation between industry and the University	Available resources
2. Support to endowments and the University Foundation	Available resources
3. Curriculum	Curricular offering

(*table continues*)

4. Student/graduate communication/presentation skills	Curricular offering
5. Cost of employee replacement	Marketing strategies & tools
6. Employee educational reimbursement	Marketing strategies & tools
7. Employee recruiting and retention	Marketing strategies & tools
8. Market environment and opportunities	Marketing strategies & tools
9. Outreach	Marketing strategies & tools
10. Student Coop, Internship, and Summer Hire programs	Marketing strategies & tools
11. The opinion of industry regarding the support received from higher education	Success Assessment

Phase III of this study integrated and synthesized a number of artifacts in the form of meeting minutes, documents, field notes, and observations; influenced by experiences accumulated over the period of this study to develop a vision of what the Engineering Program should look like in order to meet the needs of the industry in the region. Meeting minutes include participation in such regional organizations as the Math, Science, Engineering, and Technology Consortium, the Local Board of Trade Education Committee, attendance at various economic outlook conferences, and at the Competitive Crisis Council. This phase culminated with a gap analysis that determined the difference between *what is* and *what should be* in order to draw conclusions and develop recommendations to guide planning and decision making (For a complete discussion of the assessment data collected in Phases I, II, and III see reference 6).

Significant Findings

The major findings are summarized for all three phases by research question.

Research Question 1: What is the demographic information from regional organizations that would support an engineering program at a State University remote location?

Phase I data showed that 41.7 % of the reporting organizations are planning to hire between 1 and 5 new graduates annually, 16.7% are planning between 6 and 10 new graduates, 5.6% are planning on 11 to 15 new graduates, and 25% are planning to hire 21 or more new graduates annually. Conservatively, these data indicate that 200 to 300 newly graduated engineers will be hired annually.

Research Question 2: What are the available resources to support development of a regional learning center for engineering?

Inspection of the Phase I survey data showed that organizations prefer supporting students (see Figure 2). Sixteen of 21 respondents to the question of providing support to the local engineering program indicated that they would participate in design projects while only 1 of 21 respondents indicated that they would finance facility construction or fund infrastructure development. There were no responses to the choice of endowing faculty. Phase II results;

however, clarified that organizations believe that tangible support for endowing faculty is more difficult to justify than other forms but it is not impossible to accomplish. One respondent explained that the reason that it is difficult to obtain tangible support is because of the high demand for philanthropy coupled with a low supply of philanthropists.

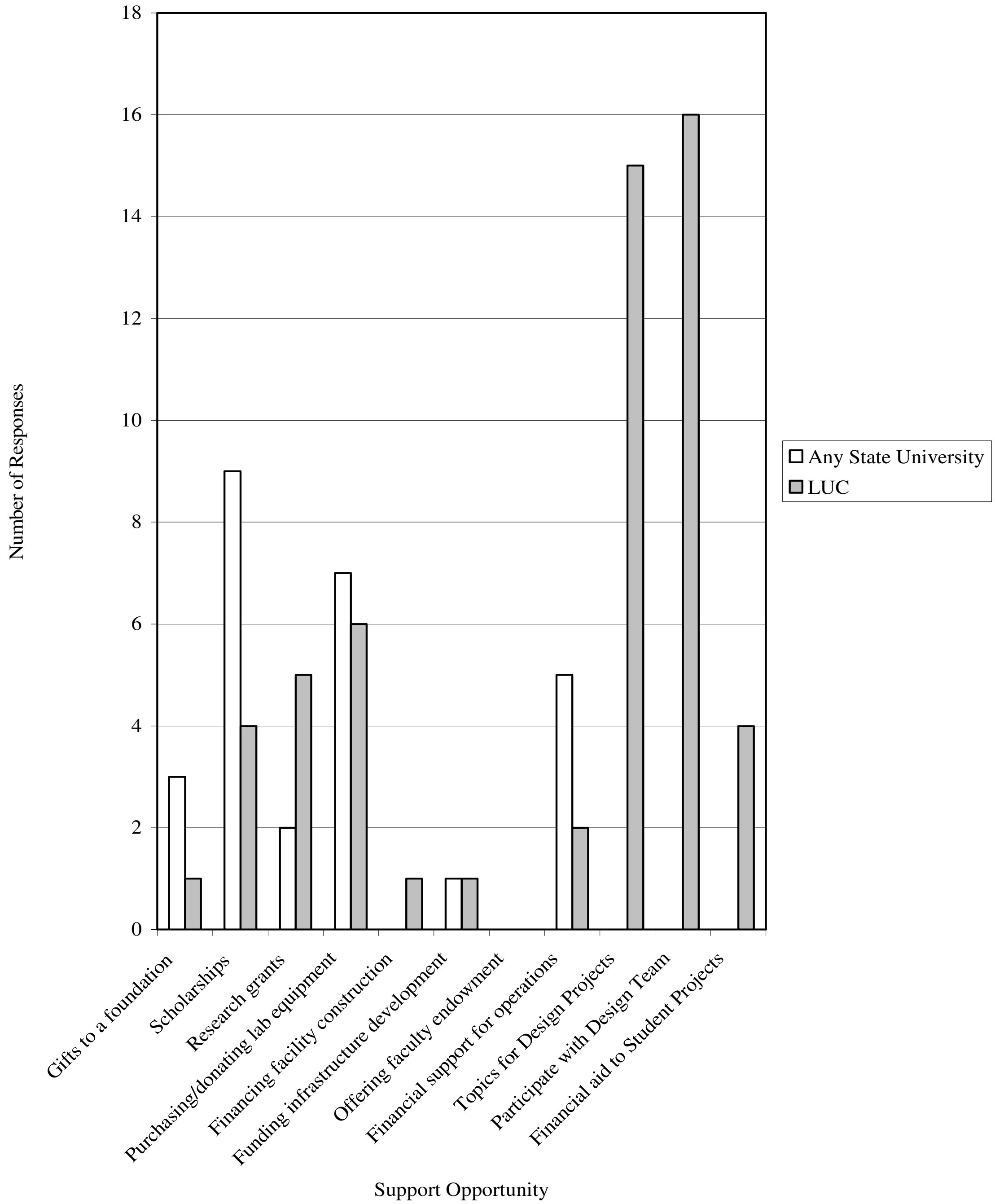

Figure 2: Survey responses indicated limited industry interest in providing tangible support.

Support for providing student work experience is significant with 65 % of the respondents answering this Phase I question. Opportunities to cooperate were identified as training, special topics classes, meeting educational needs, working together on special projects, and participating in active outreach to interest young students in engineering careers. The Building Industry respondents offered that the University had largely ignored their industry.

Research Question 3: What curricular offerings in engineering should be delivered?

The Phase I results show that, at both the undergraduate and the graduate level, Mechanical, Electrical, and Aerospace Engineering are the primary disciplines required by industry (see Figure 3). The Phase II data indicated that Computer Engineering, due to the hardware/software integration skills developed by this curriculum is of value to industry. The loss of corporate knowledge resulting from the aging of the work force precipitates the need for specialized courses and certificate programs needed by both the Critical Case A and Critical Case C industries. Systems engineering was also identified in the Phase II and the Phase III analyses as being of more significance than is deduced from the Phase I data. The Building Industry respondents (Critical Case C) were unanimous in their recommendation to begin preparing now to develop graduates to support the future needs of their industry.

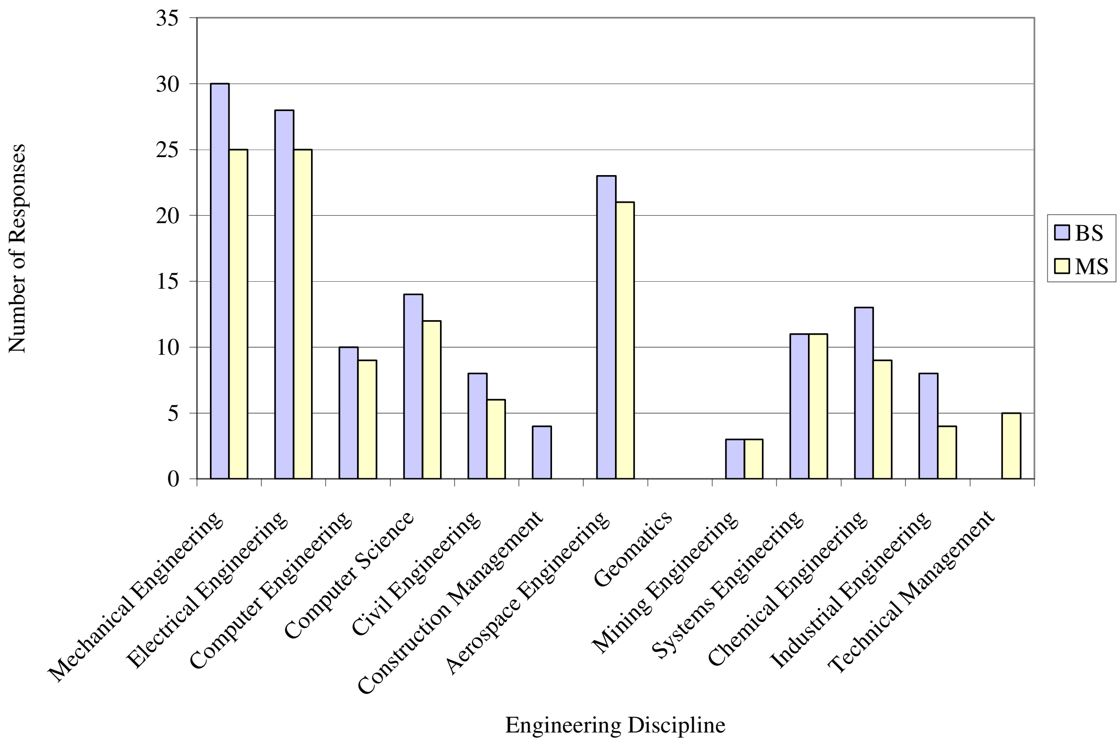

Figure 3: Industry needs greatest for mechanical, electrical, and aerospace engineers.

Both the Phase II and the Phase III analyses indicated that industry, uniformly, is concerned about new graduates' abilities for communication across disciplines, flexibility to work in a multidisciplinary environment, and with presentation skills. Project and program management were also addressed by respondents indicating the need for a Technical Management (Engineering Management) graduate program.

Research Question 4: What are the marketing strategies and tools that may be effective in student recruitment?

The Phase I data showed that 13 of 39 respondents were not aware of the local engineering program. Key industry executives interviewed in Phase II indicated that they were unaware of any benefit derived from the local engineering program.

The high cost of living in California was identified as an impediment to recruiting from outside the area as are the environment of the high desert and the lack of social amenities available in the region. These factors also significantly impact employee retention particularly for the larger organizations. For this reason industry is indicating a strong preference for locally educated engineers. The Building Industry additionally suffers from a boom-or-bust economic environment; however, there is a sufficient level of sustained business activity resulting from municipal requirements to "catch up" with infrastructure development during the lean times to accommodate locally educated engineers assuming a degree of job mobility.

The market for engineers in the region will remain strong due to the aging work force and the unique physical environment that exists for research and test activities in the Aerospace Industry. Another factor that will sustain the market is the recently acquired ability of the government organizations in the region to compete for commercial contracts.

In terms of marketing the local engineering program to the industry in the region, mass media marketing should be minimal due to the fragmentation that exists in media clientele. Targeted methods such as direct email monthly news letters are recommended by respondents.

Key factors in student recruiting are the ability to provide students with relevant curricula, opportunities for students to obtain industry experience, and a preference for employment for locally educated graduates. Another factor that must be emphasized, not only by the University but by industry as well, is the intrinsic value of the work performed by engineers in the region.

Research Question 5: How should the success of the regional learning center be assessed?

Phase II interview responses indicate that measuring the success of the program must be based on measuring industry satisfaction with the support received from the University and with industry feedback regarding the quality of the key attributes that locally educated graduates poses. The local engineering program business plan features which facilitate achievement of the student enrollment growth rate are: increasing the community college base from which transfer students can be drawn, increasing the enrollment in engineering at the community college level through outreach, and by expanding the engineering programs offered by the local engineering program.

Gap Analysis

The gap analysis, based on a force-field analysis (see Figures 4 and 5) used to evaluate findings revealed that funding to support a full time Electrical and Computer Engineering faculty member assigned to the local engineering program is an obvious gap as is the current lack of a graduate Mechanical Engineering program. In terms of expansion of the undergraduate program, Computer Engineering and Construction Management are the easiest curriculum expansions to implement. The Engineering Management curriculum at the graduate level, deploying the revised Mechanical Engineering program, along with specialized courses and certificate programs developed and delivered by qualified industry personnel hired as adjunct professors by the University are activities that industry has indicated will have significant benefit. Other programs requiring more resources and effort, such as Civil Engineering and Geomatics (Land Surveying) need to be addressed through planning with industry support.

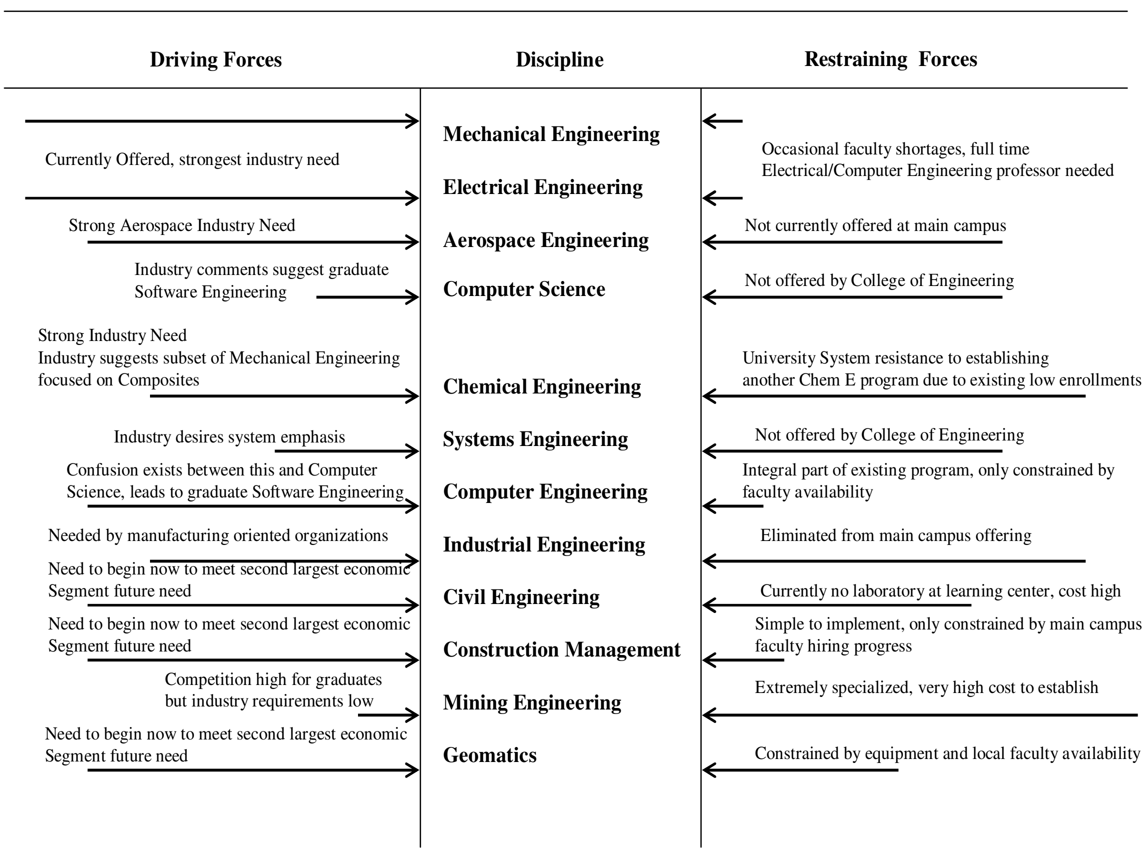

Figure 4: The force-field analysis for the undergraduate curriculum identifies the industry needs and provides a means of prioritization.

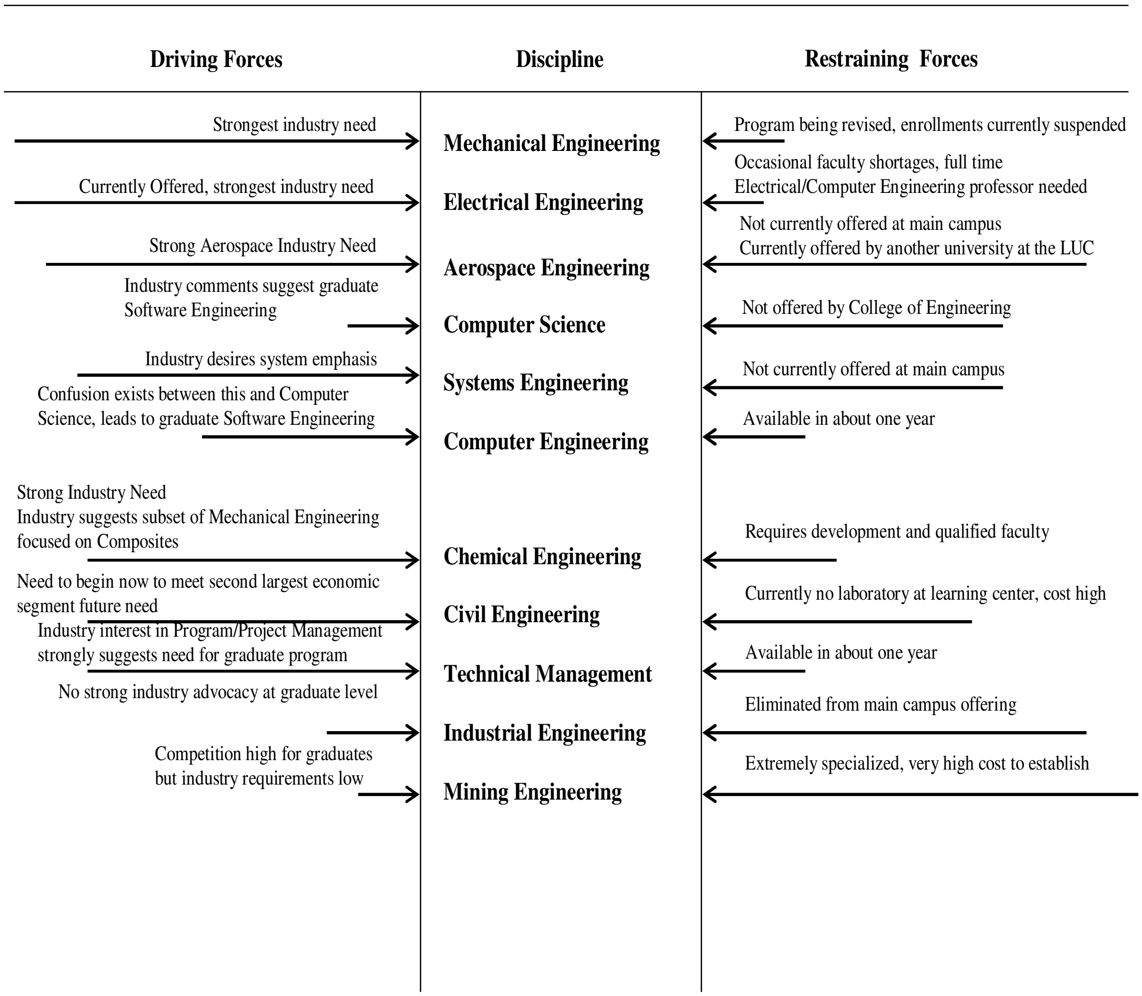

Figure 5: The force-field analysis for the graduate curriculum identifies the industry needs and provides a means of prioritization.

Resulting Engineering Education Program Development

The model that is evolving, in the high desert, is an alternative to the traditional brick and mortar undergraduate engineering education (see Figure 6). In this model, upper division instruction only is provided by the degree granting institution and requires the development of partnerships with the region's community colleges to provide the explicit lower division curriculum that students require to meet their degree objectives.

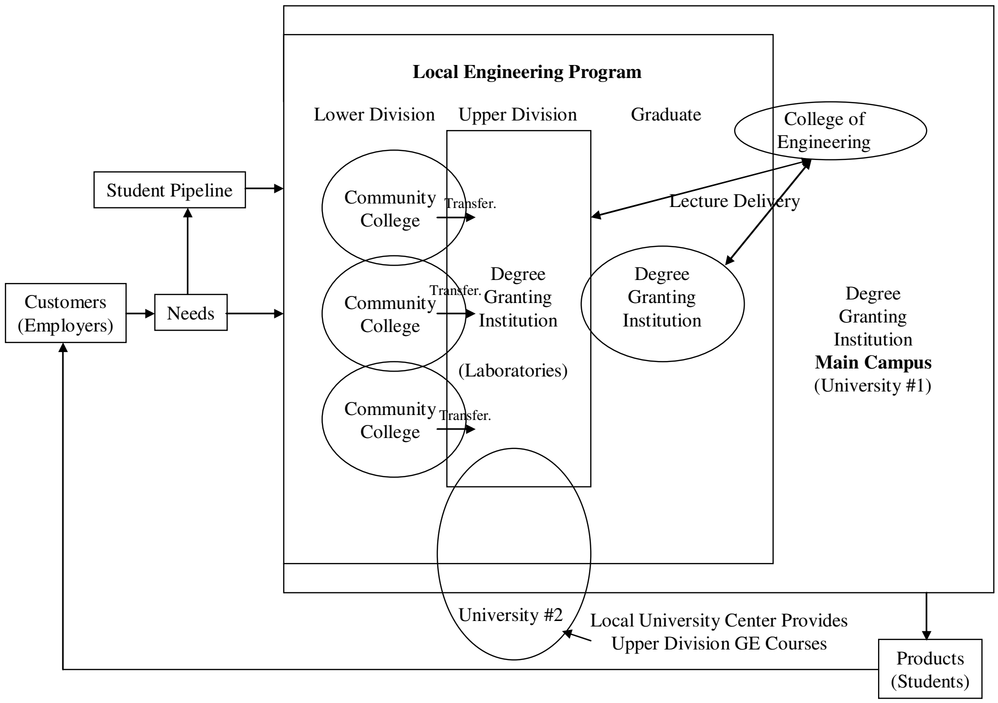

Figure 6: Local Engineering Program Model in its Current State of Evolution

Upper division instruction is provided through the use of interactive live-broadcast lectures and classes that combine students from the distant and main campus locations. Instruction is also bidirectional in that some instruction originates from the distant location which takes advantage of individuals from the highly skilled workforce. The local university center hosts the laboratories required for upper division students and is centrally located with respect to the population distribution.

Lower division engineering, general education and laboratory experiences are provided by the community colleges. The development of the lower division curriculum occurs in partnership with the community colleges and is in the process of being designed to be consistent between the participating community colleges such that course articulation with the degree granting institution is simplified. Curriculum and advising are the subjects of Memorandums of Understanding with each of the partner community colleges. Student advising is accomplished jointly between specified counselors at the community college and the staff and faculty at the university extension and main campus. Students are encouraged to review their progress each semester as they progress through their undergraduate (including lower division) curriculum and are provided with advising sheets detailing the program with course numbers from both institutions.

The advising sheets provide the students with the explicit course requirements by community college course number and descriptor as well as the upper division requirements once the student has successfully transferred (see Figure 7). The first four blocks of the advising sheet define the lower division requirements while the second four blocks provide the student with the information required once the transfer is accomplished. A separate advising sheet is developed for each participating community college. Multiple community college partnerships also provide students with the opportunity to obtain classes, known to articulate for their degree objective, from more than one campus. The students' close relationship with the degree granting institution during their lower division experience also helps to assure that students stay on their study plan and can transfer successfully.

University #2, shown in Figure 6, is a manifestation of the regional consortium that has developed in the high desert. University #2 is another public university that has established a center in Lancaster but it does not have an engineering program. Due to the local convenience that University #2 provides, a Memorandum of Understanding (MOU) was established with the engineering degree granting institution to provide upper division general education requirements to the local engineering program students. University #2 does provide; however, various student services that would not otherwise be available. The same MOU that provides for upper division general education requirements also provides for such services as student health service, library, and *Interactive Television (ITV)* technicians that also provide examination proctoring and that handle transmission and distribution of student homework assignments.

Because of the distance from the main campus (over 200 miles) engineering laboratories were established at the distant site in the spring and summer of 2007. Laboratories were developed because the laboratory experience is essential to the quality of engineering education[18]. Laboratory experiences are provided at the local university center by instructors on-site. Laboratory equipment has been specified by the main campus and procured in accordance with the requirements of the College of Engineering in order to provide students with the same laboratory experience that their main campus counterparts receive. The City has provided a building which houses a mechanical engineering laboratory capable of providing students with product development, fluid mechanics, heat transfer, and thermodynamics laboratory experiences.

The local university center hosts an electrical engineering laboratory equipped to provide students with essential laboratory experiences required to graduate. Progress is being made to expand laboratory capabilities to address Edwards AFB Flight Test needs (primarily instrumentation) as well. The mechanical engineering laboratory includes both a subsonic and a supersonic wind tunnel. Experimental equipment is modular and mobile (except for machining equipment) to allow easy laboratory reconfiguration for the various laboratory classes offered.

The foundation of the local program for this model is based on the traditional lecture style, laboratories, and project based classes. There has been no effort made at the main campus or in Lancaster to conduct asynchronous classes, or move to an on-line delivery mode, and there has been no effort to either modify curriculum or to adjust teaching style to accommodate the technology. Lectures are simply broadcast live and the technology allows interaction between the main campus class room and the distant class room. Lecturers at the distance location use the same syllabi and laboratory manuals as the main campus instructors. There is recognition; however, that additional preparation and forethought is required in the transmission of homework, quizzes, and tests, as well as material distributed during class. Contingencies for failures of the technology must also be predetermined[23] and include recording and posting lectures where distance students can access missed material using a PC.

Public University Engineering Program
Specific Community College
Mechanical Engineering Program
Recommended Program Sequence

Bachelor of Science Degree

Student_______________________________ID#_________________Advisor__________________

Telephone______________________Catolog Year___________________Grad Date______________

E-Mail_________________________

ADVISING SHEET **MAJOR CODE: 054402**

Fall First Semester at CC		**Spring Second Semester at CC**	
Name (Units)	**Taken**	**Name (Units)**	**Taken**
Math 150 – Calculus I – (5)	_______	Math 160 – Calculus II – (5)	_______
PHYS 110 – General Physics and Lab –(5)	_______	Phys 120 – General Physics and Lab(5)	_______
ENGR 110 – Intro to Engineering – (3)	_______	ENGR 115– Basic Engineering Drawing-(3)	_______
ENGL 101 – Freshman Comp/Area A2- (3)	_______	Comm 101 – Intro to Speaking/Area A1-(3)	_______
CIS 161 – Intro to C Programming –(3)	_______	Phil 105 – Ethics/Area C2-(3)	_______
Art – Area C1-(3)*	_______		
Fall Third Semester at CC		**Spring Fourth Semester at CC**	
Name (Units)	**Taken**	**Name (Units)**	**Taken**
Math 250 – Calculus III –(5)	_______	Math 230 – Differential Equation –(4)	_______
ENGR 230 – Circuit Analysis-(4)	_______	ENGR 130/L – Material Science & Lab –(4)	_______
ENGR 210 – Statics-(3)	_______	Hist 107 or 108 – US History/Area D1-(3)	_______
Chem 110 – Chemistry and Lab/Area B1-(5)	_______	Econ 101 or 102 – Economics/ Area D3-(3)	_______
POLSI 101 or 102 – Political Science/Area D2-(3)	_______	BIOL 101 – Biology/Lab Area B2&3-(4)	_______
PHYS 211 – General Physics and Lab –(5)	_______		
Fall Fifth Semester		**Spring Sixth Semester**	
Name (Units)	**Taken**	**Name (Units)**	**Taken**
ME 125 – Engineering Stats in Experimentation-(3)	______	ME 116 – Fluid Mechanics-(3)	______
ME 112 – Engineering Dynamics-(3)	______	ME 118 – Fluid Mechanics Lab-(1)	______
ME 115 – Instrumentation & Measurement Lab-(1)	______	ME 134 – Fundamentals of Machine Design-(3)	______
CE 121 – Mechanics of Materials(-3)	______	ME 136 – Thermodynamics-(3)	______
ME 95 – Engineering Product Development-(2)	______	ME 140 – Advanced Engineering Analysis-(3)	______
ME 2 - Computer Applications in ME –(1)	______		
		PHIL 316 – Philosophy– (5 QTR)	______
*Completion of Writing Exam	______		
Fall Seventh Semester		**Spring Eighth Semester**	
Name (Units)	**Taken**	**Name (Units)**	**Taken**
ME 145 – Heat and Mass Transfer –(3)	______	ME 155 – Elements of Systems Design –(3)	______
ME 154 – Design of Machine Elements –(3)	______	ME 166 – Design –(3)	______
ME 156 – Advanced Thermodynamics –(3)	______	ME Tech Area B – 3 units	______
ME 159 – Mechanical Engineering Lab –(1)	______	ME 135 – Engineering Product Design-(3)	______
ME Tech Area A – 3 units	______		
PLSI 304 – Political Science – (5 QTR)	______		

3 units Technical Area A courses: select from ME 137,142, 144, 146, 162 or 164 3 units Technical Area B courses: ME 180, 190, 191T, ECE 121, 121L, 155
*Art – Recommended 100,101,102,110,or 147 *** Additional Requirement: Must pass the university writing exam or take IT 198W online course during the fifth semster.**

Figure 7: Example advising sheet for mechanical engineering

The evolution of the model is not yet complete. There are many factors, such as the technology employed, current economic conditions, processes, procedures, and instructional methods that require focused attention before the model can be fully matured.

Conclusions and Current Status

The entrepreneurial challenges faced by the key participants in developing an engineering program in the high desert revolve largely around three factors. The first factor is that the existing public university has made the decision to withdraw its participation over a four semester period commencing with the fall 2009 semester and concluding at the end of the spring 2011 semester. The decision, on the part of the existing public university, is exacerbated by the second factor which is the current state budget crisis. The crisis has caused the state university system to implement a plan to reduce system-wide enrollments by 40,000 students over two years thereby eliminating Full Time Equivalent Students (FTES) as a growth or sustaining incentive. The third factor is the limited industry interest in providing fiscal support for operations and faculty. This third factor is not surprising based on the fact that the major employers in the region are federal government organizations which are limited to investing in tangible support such as facilities and equipment as apposed to providing resources to cash investments such as endowments.

There is a sufficient need in the region for locally trained engineers. The local population demographics strongly indicate the need for a public university. The heavy government related engineering work in the region demands that a university offer ABET accredited programs. The regional job market, just to replace the existing aging engineering staff, is 200 to 300 newly graduated engineers annually. The primary industry requirements are for mechanical, electrical, and aerospace engineers although recovery in the building industry would create demand for civil engineers and construction management graduates as well.

In spite of the challenges faced by the key participants, opportunities are abundant. Discussions are underway with two public universities interested in providing engineering programs to the region. The engaged industry partners understand the need to develop a sustainable, regionally scalable enterprise for delivering engineering education. An innovative combination of privately sponsored endowment, government investment in main campus facilities and equipment, paid sabbaticals, faculty summer hire programs, all coupled with programs offered through university extension is being considered.

The rationale, used by the current university, for withdrawing is being addressed by seeking interested universities with sufficient capacity to accept the effort required to create a successful enterprise. A grant is being used to modernize the classrooms used to deliver live interactive broadcast lectures and procurement has been initiated. Additionally, the pipeline of students interested in studying engineering locally appears to be filling through the efforts of the several educational consortiums involved in creating a college going culture.

The developing model for delivering engineering education to a distant location is successful. The program is yielding graduates at both the bachelor's and the master's level. Local program graduates are being employed by the region's industry. Conversations with industry employers indicate that they are very satisfied with the local program graduates that they have hired. Industry, the educational community, and the local municipality remain active and engaged in the effort to develop a local engineering program for the high desert region of California.

Vision

The rationale for establishing an extension for training engineers in the high desert of California is to produce locally educated engineering graduates to meet regional industry needs and to improve the industry return on employee retention investment. This focus, however, does not preclude the opportunity to provide students with an engineering education which includes education in entrepreneurship as an integral part of their upper division experience. The communication skills, the ability to work in teams, and the skills necessary for rapid assimilation into the work force overlap the skill set expressed by industry as required of new graduates. The entrepreneurial skills that students will acquire are required to develop the internal entrepreneurship mindset required to sustain enterprises in a global economy. The experience of enterprise creation necessitated by the withdrawal of the existing university provides the ability to take advantage of the opportunity for infusion of the experience gained as curriculum is revised to meet the requirements of a new university.

The literature regarding engineering entrepreneurship indicates that learning outcomes for students need to focus on effective communication, the ability to function on multidisciplinary teams, the ability to provide leadership, ethical conduct and decision making, the ability to recognize opportunities, persistence, creative and innovative problem solving, the ability to manage ambiguity, as well as the application of sound business practices[24]. Factors that the experience of enterprise creation have illuminated also include defining customers and products, understanding customer needs, acquiring data relevant to decision making, documenting activities to clarify understanding and allow recovery of information, understanding the social, business, and political environment, understanding the value of networking and relationship development and understanding the importance of coalition building[25]. Observations from the entrepreneurial experience include the realization that understanding customer needs was a valuable first step in the networking process that has resulted in the development of close relationships. The data gleaned was a valuable first step in establishing a relevant dialog with customer leadership that has allowed development of a consortium of engaged partners and has formed the basis for decision making. Documentation throughout the process has allowed internalization of issues which has clarified understanding.

The class size constraints that exist at the extension preclude the ability to develop specific entrepreneurial courses; therefore, infusion of the entrepreneurship content throughout the curriculum is being contemplated. Infusion of the learning outcomes focus and the experience gained will begin with the transfer student orientation, continue to be reinforced and expanded during course deliveries, and culminate with a multidisciplinary capstone design experience[24]. Much of the learning outcomes focus is consistent with ABET criteria, the expressed customer need for graduates with strong communication skills, and can be coupled with experience "… to encourage an education and research culture that promotes innovation, creativity, and leadership"[26].

Although the curriculum is not yet formalized, the intent is to use inquiry-based student-centered learning objectives in orientation and in each class offered. Individual and team-based oral and written presentations relevant to the material under study will be defined that emphasize scientific critical thinking and problem solving[27]. Infusion of the learning outcomes focus and the experience gained will be planned to culminate in the senior capstone design series classes augmented by cooperative education, internship or other relevant student work experience obtained as a requirement of the course of study. The capstone design series is envisioned to be a cross-disciplinary effort[28] that includes business plan/business case development, presentation, formal reporting, and proof of concept demonstration/test. By infusing entrepreneurship elements throughout the curriculum in a manner relevant to the topics under study, integrated during a senior cross-disciplinary capstone effort, students will gain a capacity for exercising entrepreneurship.

The research conducted to understand the government and industry regional needs, the force field analysis that has provided insight into driving and restraining forces, the customer/product focus, the resulting model development, and the relationship building that have occurred during the process have laid a solid foundation for a second round of enterprise creation necessitated by the phase out of the current university. The experience gained by the local program practitioners has highlighted the skill set necessary to create an entrepreneurial mind set in engineering graduates. A new university provides the opportunity to address entrepreneurship skills by infusion throughout the upper division curriculum rather than in dedicated courses.

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