AC 2011-1620: EXPLOITING A DIFFICULT ENVIRONMENT: MATURING A MODEL FOR AN ENGINEERING DEGREE COMPLETION PROGRAM IN PARTNERSHIP WITH MULTIPLE COMMUNITY COLLEGES

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Exploiting a Difficult Environment: Maturing a Model for an Engineering Degree Completion Program in Partnership with Multiple Community Colleges

Abstract

The evolution of a model for a transfer student degree program for mechanical and electrical engineering was initiated based on a partnership with a single community college which provided articulating course work designed to meet the requirements of a degree granting state university. The single community college was not providing a sufficient number of transfer students to justify the program investment so a second community college partnership was developed.

The existing program has been a state supported program but the economic conditions dictate that a state supported program, removed by distance from the main campus, is no longer viable. As a result of the impact on the state university system a new program is being launched through extension.

The evolution of the model for the existing program has been largely reactionary but the current economic conditions require that the model be evaluated with data driven forethought and planning. The community college pipeline has been found to be inadequate in providing a sufficient number of qualified transfers to maintain a viable upper division engineering program. Subsequent data collected from a number of community colleges has confirmed that multiple community college partners with articulating programs are required to provide a sufficient transfer pool.

The new launch has allowed the opportunity to review the model from the perspective of what has been learned and to consider implications based on data collected through surveys and market analysis. The new launch also has afforded the opportunity to mature the model through considering the integration of the transformation models for engineering education described by Owens and Fortenberry and to consider the application of the supply chain approach suggested by Al-Turki, Duffuaa, Ayar, and Demirel.

The issues surrounding maturation of this model, the existing impact resulting from the economic conditions, the pertinent data, and the nature of the effort required to mature this model are discussed. The conditions necessary for program success are defined and the strategies required to address the necessary conditions are developed as is the current program status.

Introduction

> We live in tumultuous times, yet Americans know instinctively that our way forward is not to retreat or to re-trench. The way forward is to become more open, more experimental and to embrace the unknown. We cannot turn inward, nor can we allow our institutions to become overly centralized and risk averse [1] (p. 8).

In 2004 a city in a Sothern California region renovated an existing property for the use of public universities. The intent was to draw baccalaureate and graduate programs to the region to support local high technology industries. Programs in engineering were of primary interest and this event initiated the evolution of a model for delivering a baccalaureate program designed to take advantage of the local community college to offer bachelor degrees in mechanical and electrical engineering. Mechanical and electrical engineering degrees were reported by the local industries as being their primary needs. Concurrent with the opening of the renovated facility, a state university began offering a program, in cooperation with the local community college, in mechanical and electrical engineering. The program was offered through the normal state funded mechanisms. Early in 2009 the university had to make a decision to phase out the program due to a number of factors principal among them being the need to focus their allocation of resources where they were most needed [2].

The economic conditions in California have had an unprecedented impact on the state university system over the last two years. The system has had to implement furloughs, layoffs, student fee increases [3], enrollment limitations, and a planned system wide enrollment reduction [4]. It is doubtful that the system will recover to a pre-downturn posture and the most recent state budget news is not encouraging. The most recent budget proposal from the Governor provides an 18% budget reduction for the California State University System [5]. New programs must, therefore, focus on being sustainable without support from the state budget.

In the current economic environment start-up of a new state-supported program is not feasible; therefore, the degree-granting institution must develop a realistic financial model that rapidly leads to a self-sustaining program. Such a financial model must account for all of the costs associated with delivering programs at a remote location. It must define external support requirements for program development and start-up. Revenue generation assumptions must also be based realistically on building a sustainable level of student enrollment (the effort must ultimately depend solely on student fees).

The degree completion program, scheduled to offer classes beginning with the fall 2011 semester, is designed around a cohort system of 30 mechanical and 30 electrical engineering students admitted annually. The cohorts will enter a seven-trimester program designed to accommodate a relevant industry experience during the first summer trimester.

The reliance on community college partnerships to supply qualified transfer students requires understanding community college pre-engineering program enrollments. The shift from a state-supported program to a self-supported program has afforded the opportunity to redirect the evolving model for engineering education by integrating a transformational model and by considering supply chain management in its maturation.

Community College/Pre-engineering Program Enrollment

The student pipeline enrolled in the lower division (pre-engineering) courses at the community colleges is critical to the success of the degree completion program Therefore; information was collected during the spring 2010 semester to determine the viability of the program. Thirteen community colleges and one public university that only offers pre-engineering were asked to provide their projections for student enrollments for the 2010/2011 academic year as well as the previous four years. Institutions contacted were those located within one and one half hours normal commute time from the continuing education campus. Specific classes were identified that are of particular interest to the new university's admission requirements. Spreadsheets were prepared and provided to facilitate data collection. Requests were directed to institutional research directors and cognizant deans/department chairs responsible for the engineering curriculum. Six community colleges and one university responded. The information obtained is summarized in Table 1. The total student population for the responding institutions is approximately 116,000.

Year	Semester	College Algebra	College Trigometry	Calculus I	Calculus II	Calculus III	Ordinary Differential Equations	Physics I (mechanics)	Physics II (Electricity & magnetism)	General Chemistry I	Engineering Statics (prerequisite Calculus I)	Electrical Circuits (prerequisite Calculus I)
2005/2006		4,640	1,870	1,904	1,108	624	301	763	399	1,737	73	114
2006/2007		5,050	1,784	2,129	1,220	645	275	601	307	1,732	97	85
2007/2008		5,090	2,056	2,254	1,271	637	307	583	301	1,796	72	109
2008/2009		5,581	2,362	2,451	1,424	655	520	751	385	1,907	93	135
2009/2010		5,027	2,062	2,408	1,447	812	390	797	398	1,972	160	182
Total		25388	10134	11146	6470	3373	1793	3495	1790	9144	495	625
Academic Year Average		**5078**	**2027**	**2229**	**1294**	**675**	**359**	**699**	**358**	**1829**	**99**	**125**
% of Total Student Population		4.38%	1.75%	1.92%	1.12%	0.58%	0.31%	0.60%	0.31%	1.58%	0.09%	0.11%

Table 1. Summary Data: Enrollment in Math, Science, and Engineering Courses.

Table 1 identifies the challenge and the opportunity presented to the degree completion program and confirms the need to partner with multiple community colleges in order to develop a sufficient pool of qualified transfer students. Note that the seven responding institutions project only 160 students would complete Statics and 182 would complete Electric Circuits. This represents a significant increase over previous years and is largely due to the effect of the partnerships established with two community colleges. The enrollment totals for Statics and Electric Circuits, however, are still low and the numbers of students completing the math, science, and engineering courses of interest at these institutions throughout the community college system is disappointing.

The economic crisis in the state has created the need for the state university system to control state-supported enrollments. In fact, over the previous two years the state university system has attempted to reduce system wide enrollments by 40,000 students [4]. Although this effort has been relaxed, it has created a transfer pool of students waiting for admission. We conducted a market survey to assess transfer student interest in the degree completion program.

Approximately 270 students who were denied admission, but who were eligible for upper-division transfer to the university engineering program in mechanical and electrical engineering were requested to respond to a questionnaire administered through Survey Monkey. Approximately 50 students responded to the survey. Of these 31 students or 62% indicated an interest in the degree completion program. Based on this initial study the assumption has been made that the program will draw students from a larger pool of community colleges. The attraction for these students is assumed, as well, to be their interest in the region's industries.

The data collected from the community colleges and from the existing transfer student pool are encouraging in spite of the low number of student enrollments in STEM related classes.

Obtaining sufficient transfer students to populate the initial cohorts looks feasible with significant effort. The data suggests that the partnerships developed with community colleges will need to focus on increasing the student enrollments in STEM classes and that partnerships with multiple community colleges will be required. The rate of transfer student capture that can be anticipated for the degree completion program is unclear; however, a significant opportunity exists for the program to contribute to the development of engineering education, specifically, and STEM related student enrollments in general.

An Evolving Model

The model for this program, although evolving since 2004, will be impacted by several key elements that are not in common practice in baccalaureate engineering programs. This program is being developed through Continuing Education as a self-supporting program located remotely from the home campus.

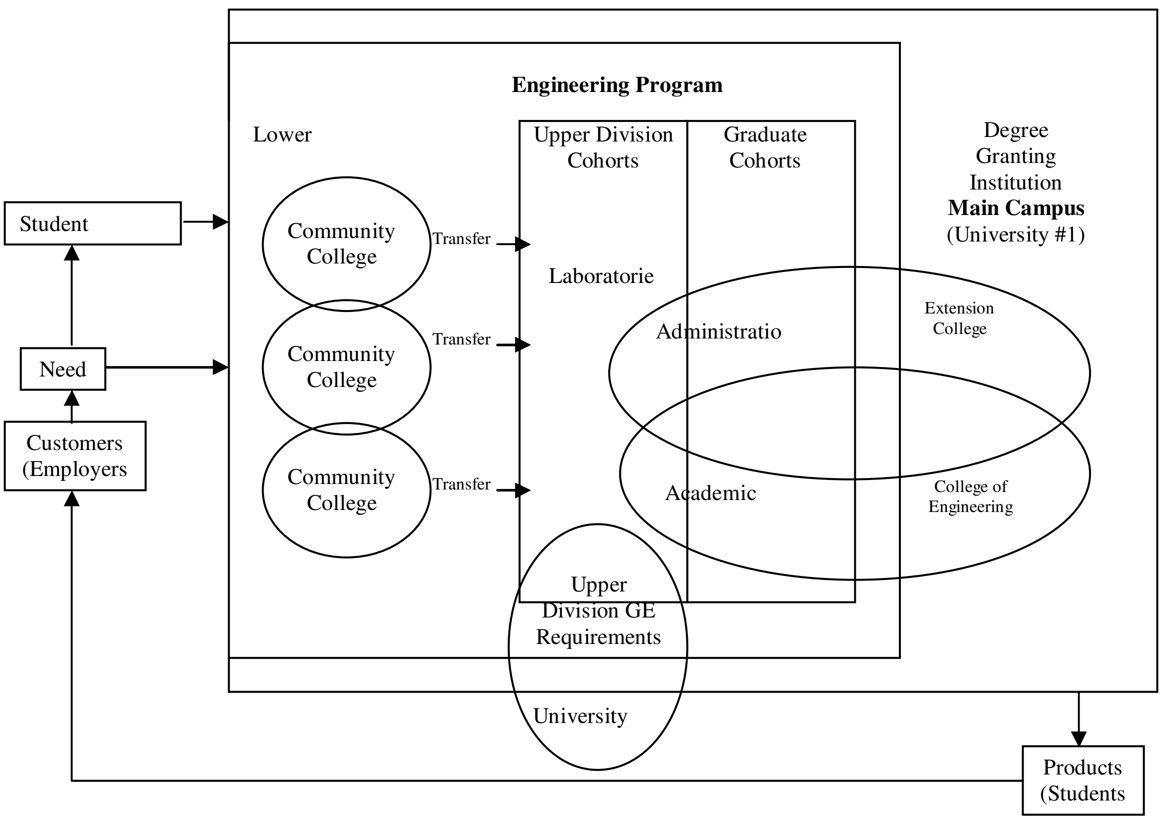

Figure 1. Evolving Degree Completion/Graduate Engineering Program Model [2] (p. 8)

The key elements that will impact the evolving model result from the implementation of a cohort model conducted within the framework of a trimester system and with a requirement for relevant industry experience (internships, coops, etc.) during the upper division. The model, as reported at the 2010 ASEE Zone IV conference, is shown in Figure 1.

Significant changes are occurring as the new lead university defines the program to be offered. Initially, the new lead university will focus on the baccalaureate degree completion program and will defer planning the graduate program until the success of the degree completion program is secured. Planning the graduate program will be further complicated by the presence of more than one state university offering graduate engineering at the extension campus. This will necessitate cooperation between universities to avoid overlap and assure mutual success. The modified model that excludes the issues relating to the graduate program is shown in Figure 2.

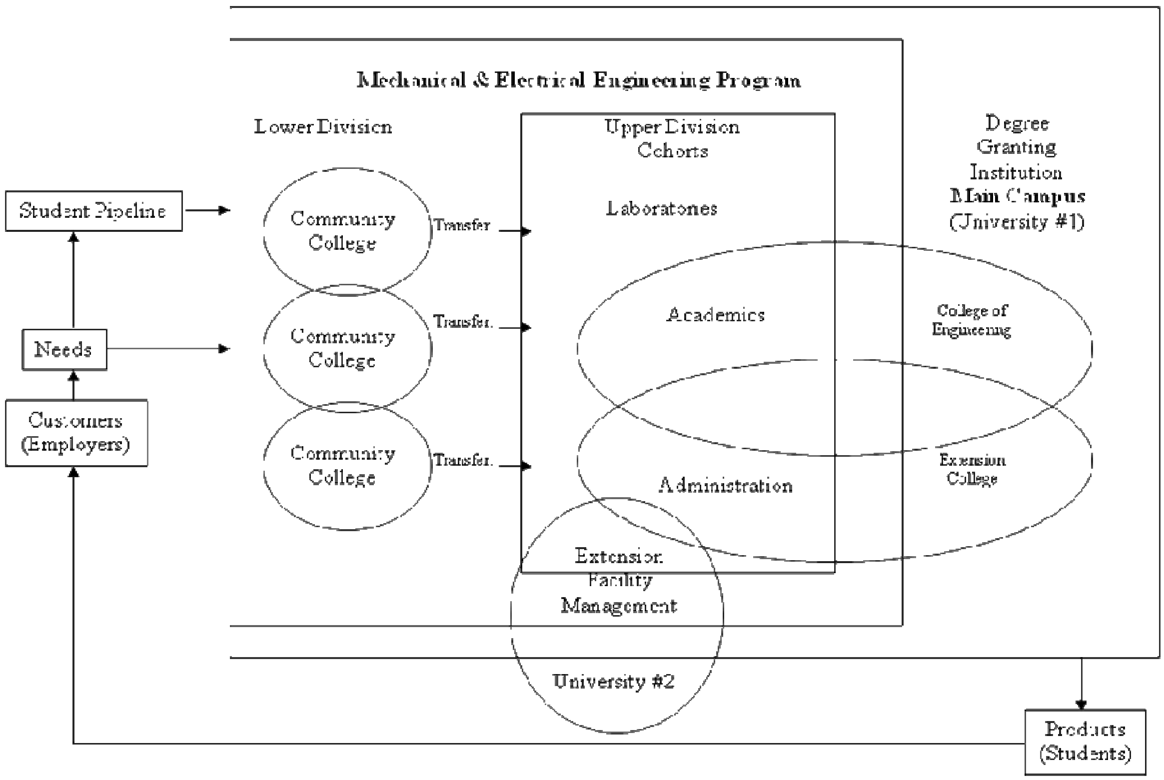

Figure2. Evolving Degree Completion Mechanical & Electrical Engineering Program Model

The development of a program by a new lead university focusing on the degree completion program allows the opportunity to consider the model from the perspective of what has been learned and data acquired. It also permits the integration of a transformational model for engineering education [6] and the use of a supply chain model [7]. Owens and Fortenberry [6] present a transformation model for engineering education which is an active environment composed of physical, psychological, social, and economic factors. In discussing the development of transformation models for engineering education Owens and Fortenberry specifically state that,

> In the Engineer of 2020 report, the student is viewed as (1) a consumer of the education system seeking preparation to become an engineer and (2) a product of the educational system (NAE 2005) (p. 432).

Describing the student as the product of the educational system is consistent with the evolution of the degree completion program and adds the dimension of placing the student as a consumer as well as a product. This view is also consistent with the realistic model of higher education proposed by Bailey & Bennett [8]. Leband and Lentz [9] further define the student as unit of production or the academic output of higher education. This view defines the student as the primary customer or consumer of higher education [10-13]. The reason for this product bias specific to engineering students is that, much like medicine and law, engineering is a professional degree. Engineering is, however, differentiated by the fact that graduates usually enter the work force after completing their baccalaureate degree [14].

The Transformation Model

The transformation model described by Owens & Fortenberry [4] identifies the operand as an input and/or output of the model. In the case of the degree completion program the operand, in state 1, represents the transfer student. State 1 being the transfer student with "… measurable characteristics specific to the engineering discipline (i.e. knowledge, skills, abilities, attitudes, etc.)" (p. 433). This state for students is ideal for the degree completion program because issues relating to remediation (short falls in student math and science preparation) and lower division retention rates are dealt with by the community college partners. At state 2 the operand will have evolved and be awarded a degree indicating proficiency in an engineering discipline sufficient to become employed. According to Owens & Fortenberry,

> Hence, states 1 and 2 are defined by the set of knowledge, skills, abilities and traits that make the transformation necessary and complete, respectively. The model is working on the operand via the operators (p.433).

The transformation model is further defined by Owens & Fortenberry [4] as being comprised of an <u>execution system</u> and an <u>executive system</u>. Each system has two subsystems. Human Resources and Support Personnel (HRS) and Organizational and Technical Resources (OTR) comprise the execution system and Engineering Concepts (EC) and Administrative Regulation (AR) comprise the executive system. The HRS relates to the teachers and learners and those, such as family and friends who provide support. The OTR is focused on the tools of the transformation. Examples of OTR are curriculum and classroom equipment and media. EC, which implicitly includes internships and co-ops, addresses competency in the engineering discipline. The AR subsystem provides structure and logistical support to the curriculum and mediates conflicts and disagreements that arise.

Based on the transformation model description, provided by Owens & Fortenberry [4] the allocation of the elements (subsystems), within the context of the degree completion program, fall largely on the University's College of Engineering. The College of Engineering and the University's College of Continuing and Professional Education (Extension College) share responsibility for the AR subsystem. This must all be accomplished in a cooperative, active environment with the community college partners. The transformation model overlaid on the degree completion program model is shown in Figure 3.

Owens & Fortenberry discuss both the utility and the validation of the transformation model. The utility of applying this transformation model to the deployment of the degree completion program can be summarized in terms of allowing the definition of goals, facilitating the evaluation of the system, and for providing visibility for the constituents relative to their effectiveness. It also allows for the identification of program development and optimization opportunities, fosters integrated thinking, provides the ability to consider assessment and continuous improvement, and accounts for the role of the student, and encourages student engagement in curriculum development.

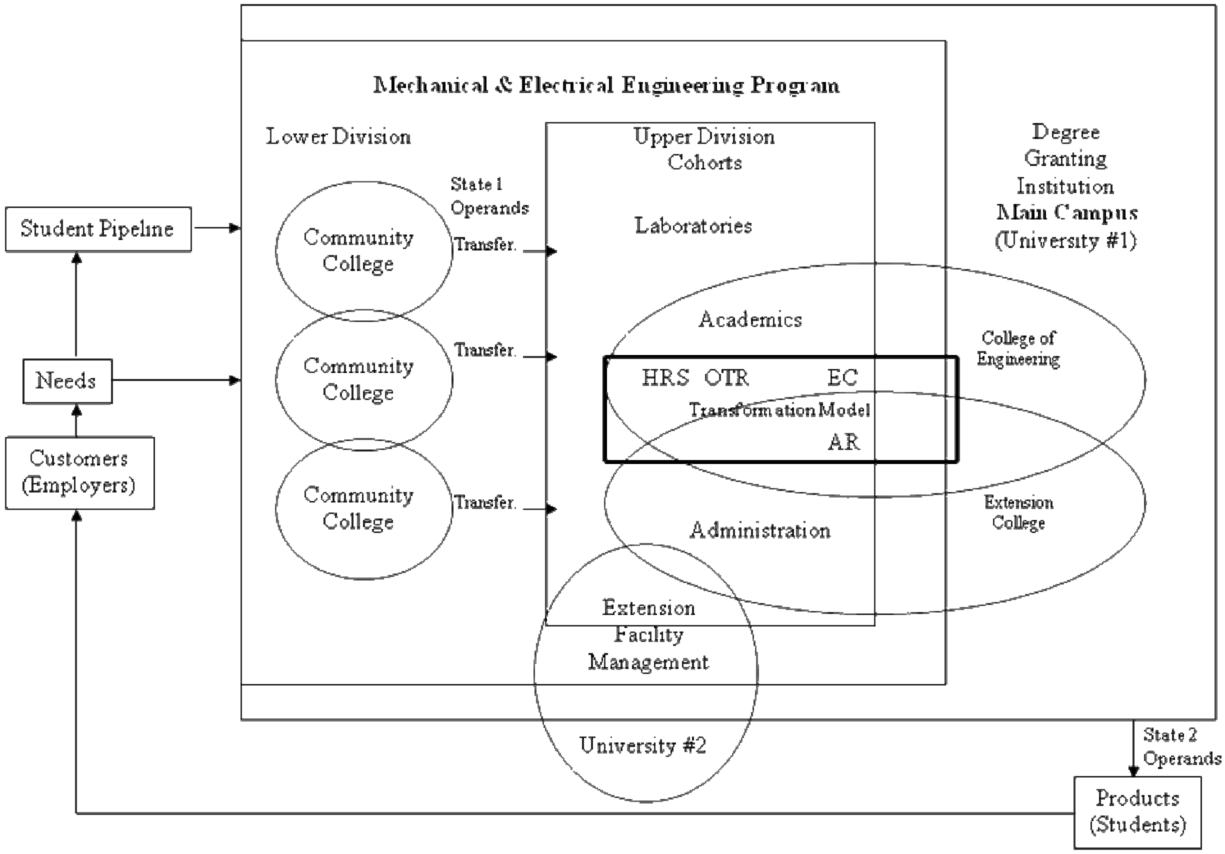

Figure 3. Transformation Model Overlaid on Degree Completion Program Model

In addressing transformation model validation Owens & Fortenberry ask the following questions (p. 437):

1. Are all elements of the transformation process necessary?
2. Is the sequence of partial processes correct in the transformation process?
3. Can the transformation process be updated to account for the new knowledge learned from the intermediate processes?
4. Does the transformation process continually deliver the necessary materials, energy and information to the operand (student) throughout their undergraduate years?
5. Is the model inclusive of the contributions of the operand to the transformation?
6. Does the transformation model meet the initial objective of transitioning the operand from the initial state to the final state?

In conclusion, Owens and Fortenberry state that, in their judgment, these questions are answered in the affirmative. The use of the transformation model for engineering education should, therefore, be of benefit to the successful deployment of a degree completion program.

The next aspect to the current evolution of this model is to consider matching educational outcomes to market needs. An objective of the degree-completion program is to supply locally trained engineers to highly technical industries located in a unique physical environment that makes retaining employees recruited from outside the region difficult. Another objective is to provide enhanced access to research opportunities to the lead university.

A Supply Chain Approach

Much of the supply chain thinking for higher education institutions (HEIs) proposed by U. M. Al-Turki, et al [7] has been adopted in evolving the degree completion program represented by the model in Figure 3. The approach, of running the program through a Continuing Education unit, creates the need to be sensitive to cost because the program must be wholly-supported through student fees. This necessitates working closely with regional industry to define the required qualifications of the stage 2 operands (graduating students) to minimize the number of electives offered, and to target the curriculum, within the context of available courses, to meet industry needs. This is displayed in the model via the feedback loop from customers (employers). The feedback described by the authors not only applies to the state 2 operands but to continuing education and retraining for the existing workforce as well.

According to U. M. Al-Turki et al,

> We refer to the collection of people with different skills and professions available for employment as 'job market'. The interaction between these components (i.e. educational institutions, workforce market and job market) can be viewed as a chain of suppliers and customer (p. 215).

The authors go on to indicate that,

> The flow in the workforce supply chain is analogous to the push production system where HEI's 'push' certain qualifications through the chain to load the workforce market with graduates that have various qualifications that might be needed and recruited by employers in the job market. The raw material here is people's minds and the final product is qualified people and hence people are the suppliers and customers and the institutions are service providers (p.215).

The authors continue their discussion by indicating that modern production systems have moved towards a pull production system where suppliers are only producing what the market orders. The approach taken in delivering the degree completion program which is a push-pull system where the programs and curriculum delivered is defined with the assistance of the industries providing the job market (taken within the context of what is available from the university).

In their article the authors conclude by suggesting two areas where customers (employers) should be allowed to penetrate the educational system in order to facilitate integration. These areas are curriculum development and information sharing. Curriculum development is represented in the Figure 3 model as being influenced by the customer needs. Information sharing is facilitated bi-directionally through the development of an active industry advisory board that works with the lead university and the partner community colleges.

Community College Partnerships

The degree-granting institution must carefully develop transfer admission requirements for students in cooperation with community colleges and help in developing articulating course in order to accomplish the required lower division student evolution. This will be accomplished through formal partnerships defined by Memorandum of Understanding with the community college partners.

In the findings of a qualitative study Kisker [15] reported that,

> Several findings emerged as important factors in creating and sustaining community college—university partnerships, including the importance of previous relationships between institutions, the significance of presidential support for partnership practices, the need for adequate and sustained funding, and the importance of maintaining a university presence on community college campuses (p. 288).

As the degree completion program transitions from one lead university to another and from a state supported program to a self-sustaining one it is apparent, from the findings of the above cited study, that the existing relationships between the current degree completion program personnel (transitioning to the new lead university) and the existing community college partners will be essential to transitioning the partnerships to the new lead university. The continuity of relationships is consistent with Kisker's [15] description of network embeddedness theory where in the author states that,

> In particular Gulati (1998) notes that "an actor in a social network can derive control advantages by being the *tertius gaudens*, or one who is situated between two other actors" (p.297). (p. 299).

Although the author was discussing the location of faculty in relationships between administration and students, the concept should hold in developing relationships between existing community college partners and a new lead university as well. This concept should hold because the local staff and faculty can utilize existing relationships to take the role of *tertius gaudens.*

The existing relationships were initially developed through contact with community college presidents. The need for presidential support from the partner community colleges has been critical in both establishing the partnerships and in sustaining the partnership efforts through a difficult situation, namely the existing university phase-out decision and the acquisition of a replacement lead university.

The partnerships with the two community colleges are already accruing benefits. The most obvious and essential benefit to the university degree completion program is qualified transfer students. The community colleges have and will continue to derive benefits as well. The existing partnership at one community college has precluded the planned closing of a physics laboratory and the college has been successful in securing industry financial support to maintain under-enrolled classes while student enrollments are developed to a sustainable level.

The university's campus has a well-equipped mechanical engineering laboratory but the electrical engineering laboratory is not sufficient for the planned increased student enrollment. Rather than expanding the existing laboratory a plan is developing for a Joint Facility Use Agreement with the nearest (five miles distant) community college to utilize their facilities and equipment in delivering upper division electrical engineering laboratory classes. This approach will provide the benefit of not duplicating facilities. It will allow the existing facility to be augmented with additional equipment required by the upper division classes. Equipment modernization will benefit both partners. The existing facility will also be more fully utilized and operating costs can be shared.

University and community college faculty and staff personnel must work closely together to develop sustainable partnerships. The university must carefully approach developing transfer requirements that do not overly encumber the community colleges with requirements that demand unique course development. The university systems in California allow a great deal of campus independence and the lower division curriculum at the various campuses varies significantly.

Additional opportunities being considered include early degree completion program student capture through dual enrollment, transfer/counseling staff joint training, and faculty advising support.

Conclusions

The economic outlook for the state budget in California dictates that new higher education programs cannot be deployed unless they are designed to be self-sustaining. The impact on the university systems will most certainly result in another round of limitations on admissions and/or class offerings that limit and reduce enrollments.

The degree completion program will afford an opportunity for a limited number of qualified students to complete baccalaureate degree objectives in mechanical and electrical engineering who might otherwise find it difficult or even impossible to do so.

The data from the community colleges suggests that an aggressive recruiting effort will be required to obtain the requisite number of students to sustain the program. The data also verifies the need for multiple community college partnerships (although budget impacts to the university systems may offer a mitigating influence).

The evolving model being deployed for the degree completion program is compatible and consistent with the goals established for the transformation model for engineering education and use of the transition model will benefit the successful deployment.

The supply chain approach has been implemented in planning and the model accounts for necessary features. A push-pull system is to be employed through industry/university/community college collaboration.

Community colleges, through the development of strong partnerships, are essential to the success of the degree completion program. Many mutual benefits result from the partnerships and a viable alternative to traditional brick and mortar engineering education institutions. These partnerships should also afford the opportunity to increase student interest in STEM related educational objectives.

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