AC 2012-5128: A STRATEGIC ANALYSIS OF GRADUATE PROGRAMS IN ENGINEERING TECHNOLOGY

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A Strategic Analysis of Graduate Programs in Engineering Technology

1. Introduction:

Engineering Technology programs have been serving our society for many years by educating future professionals with engineering principles integrated with practical experience. Twelve programs in the United States offer four-year bachelor degrees in general Engineering Technology [(1)]. General Engineering Technology degree programs offer an interdisciplinary platform. In addition, many discipline specific engineering technology degrees are offered at the bachelor's level. For example, ninety-four ABET accredited programs offer bachelor degrees in Electrical Engineering Technology in the U.S.A. Similarly, sixty-six and six ABET accredited bachelor degree programs are offered in Mechanical Engineering Technology and Industrial Engineering Technology in the United States, respectively [(1)].

A graduate program in Engineering Technology (or discipline specific Engineering Technology) is a critical component of the concerned academic unit and provides additional opportunities for professional and intellectual development at the Masters and Ph.D. level. Thus, several academic departments offering a bachelor's degree in Engineering Technology have developed graduate programs. Most of the graduate programs offer a Masters in Technology with concentrations in a specific discipline such as Electrical Engineering Technology, Engineering Technology, Innovation, Energy etc. The number of universities or departments offering Masters programs in Engineering Technology or related field is relatively low (15-20) as compared to the total number of departments offering bachelor's degrees in Engineering Technology (or a discipline specific Engineering Technology). Every university has its own framework. These graduate programs have observable variations in terms of the course work and other requirements.

As we move into the 21st century, these graduate programs will face new challenges and opportunities associated with the dynamics and the needs of the globalized society. Strategic planning is defined as 'the process of determining an institution's long term objectives and then identifying the best approaches to achieve those objectives" [(11)]. With the increasing demands on resources and changing needs of the stakeholders, periodic strategic planning is critical for any academic program, including the graduate programs for Engineering Technology. Strategic analysis is a precursor of the strategic planning process. Thus, this paper focuses on conducting a strategic analysis of graduate programs in Engineering Technology or Engineering Technology related programs. The author has adopted a systems perspective in this analysis. Based on this analysis, the author provides several recommendations for the growth of the graduate programs in Engineering

Technology. This paper does not include the Ph.D. in Engineering Technology or related discipline for the strategic analysis.

2. Strategic Analysis Process

2.1. Overview of the general structure of graduate programs in Engineering Technology

Many graduate programs in Engineering Technology (or discipline specific Engineering Technology) offer two year M.S. programs and each program requires a total of 30 -33 credits. Some programs have options to complete the Masters program by completing courses only or combining the course work with research credits. Research can be conducted using either a thesis option or paper (directed project) option. In the thesis option, the student undertakes a research problem that requires extensive research, often for a total of 6-8 credits. In the paper or directed project option, the student's research problem is of lesser magnitude, typically with a total of 3-5 credit hours. Students with a bachelor degree in Engineering or Engineering Technology can apply for the M.S. graduate programs. A few graduate programs require the GRE (graduate record examination) while others either recommend the GRE or do not require it. All the M.S. programs require a certain score in TOEFL (Test of English as foreign Language) for the international students. The makeup of the courses varies from program to program. Programs offer financial aids to the graduate students through teaching assistantships, research assistantships, fellowships, or scholarships. Some students take academic loans to cover the expenses. No program offers a Ph.D. in Engineering Technology. However, a few programs offer a Ph.D. in Technology with emphasis or options related to Engineering Technology.

Figure 1 illustrates a systems perspective of a typical graduate program as applied to Engineering Technology or discipline specific Engineering Technology. A graduate program is a designed process through which incoming graduate students progres. Upon successful completion of the process, a student obtains a degree (M.S.). The graduate program can be viewed as a product or service offered to the incoming graduate students. The incoming graduate students are considered primary stakeholders or clientele of a graduate program. The author emphasizes the unique situation specific to a graduate program - the primary stakeholder who consumes the product or service (graduate program) becomes the final product (student with a M.S. degree).

Faculty, staff, and academic units within the university who interact with a graduate student directly and contribute to the student's graduate training are first level secondary stakeholders. Along that line, companies (employer who sponsors employee(s) for graduate study), companies who hire the M.S. graduates, and the bank and organizations who offer loans or scholarships to the M.S. students during their study are considered second level secondary stakeholders.

In the U.S.A., the research conducted in higher education systems is tightly coupled with the graduate programs. Graduate students (M.S. and Ph.D.) constitute a foundation for the research programs in the academic units. Faculty members involved in research rely on M.S. and Ph.D. students to conduct and execute research projects, by hiring the graduate students as research assistants. In turn, graduate students learn about research and at the same time, the research projects fund their salary. Many times, tuition waiver and medical insurance for the graduate students are also paid from the grants. Graduate students also contribute to the teaching aspects of the academic unit when hired by the academic unit as teaching assistants. In turn, the graduate students teach or assist in teaching undergraduate classes.

2.2. Strategic analysis

Aaker [5] describes strategic analysis as a combination of external analysis and internal analysis. External analysis further embodies customer analysis, competitor analysis, market analysis and environment analysis (technological, governmental, economical, cultural, demographics etc.) which leads to opportunities, threats and trends. Internal analysis covers strength, weakness and other constraints. Other literature describes the popular tool "SWOT" (Strength, Weakness, Opportunities, and Threat) which has been used extensively for strategic analysis in different sectors, including in academia [12].

The following presents a SWOT analysis of the graduate programs (Masters only) in the United States with the framework of external and internal analysis. A generalized systems approach is adopted for this strategic analysis.

2.2.1. Internal analysis - Strength and weakness:

Table 1 lists multiple factors that can be used to assess both the strength and weakness of a graduate (M.S.) program in Engineering Technology. It is to be noted that the author focuses on this analysis from a generalized approach.

a. Undergraduate program and the reputation of the associated academic unit and University: As a graduate program is typically linked with an undergraduate program, an academic unit or department with a strong or recognized undergraduate program in Engineering Technology adds value to the graduate program. If the academic unit or program is associated with a ranked or a reputed University, this association becomes a strong desirable attribute. For example, if a graduate program in Engineering Technology is being offered from the department that is part of a national or globally ranked University, the perceived value of the graduate program increases.

b. Resources and infrastructure: Incoming graduate students look for resources and infrastructure in the academic unit, the associated college and the University. As Engineering Technology programs are associated with hands-on practical experience,

the importance of infrastructure and resources are very critical for a graduate program. If the associated University has access to quality common university resources (such as library, computational facilities, student life, career placement activities etc.), that provides a positive impact for the graduate program.

c. Financial aid and the cost of the graduate study: Financial support is an important factor for incoming graduate students. Graduate students have a variety of financial needs. A fresh graduate from Engineering Technology will look for tuition cost and additional stipend or financial support. For a domestic graduate in Engineering Technology with interests in graduate study, but with a job offer in hand, the amount and duration of the financial aid becomes a critical decision making parameter. Many of the international students look for tuition aid (at least) and preferably, additional support beyond tuition aid. With the current economic growth in India and China, some of the incoming graduate students can afford the cost of the graduate study. For them, financial aid is not a primary decision factor. Rather, the reputation of the University becomes a primary factor.

Cost for graduate study is another parallel important factor that contributes to the strength or weakness of the graduate program. Different cost structures are associated with the place of residence of the student. Tuition costs for in-state residents are different from that for the out-of-state students. Depending on the policy of the University, a different tuition structure is applied for international students. Cost-of-living for students also plays an important role. Subsidized or University housing is another positive attraction.

d. Graduate program: The key strength of the existing or a future graduate program in Engineering Technology or discipline specific Engineering Technology is its scope and technical focus. For example, if the graduate program is in M.S. Technology with emphasis in Electrical Engineering Technology, the program could emphasize in embedded system design, FPGA programming, Energy, or Sensor systems. Similarly, a M.S. in Technology with emphasis in Mechanical Engineering Technology could have technical focus in Manufacturing, Robotics &Automation, or energy sustainability.

Additional multiple parameters, i.e. the size of the graduate program (number of students), the number of courses or options available to complement the graduate program (M.S.) with other career enhancing options (minor or certificate), the availability of courses for the graduate programs, and the number of faculty active in the graduate program, also contribute to the strength of the program.

The strength of the undergraduate program should not overshadow the existing or emerging graduate program in Engineering Technology. Rather, both the undergraduate and graduate programs must complement each other. Thus, the clear definition of the

graduate program with a strong identity (irrespective of size of the program or number of students enrolled in the program) is critical to enhance the strength of the program.

e. Marketability and post-graduate employment assistance: It is important to assess the marketability of the M.S. graduates in Engineering Technology. Many times, M.S. graduates accept jobs similar to those held by B.S. graduates. It is important to know the career opportunities that the M.S. students obtain 2-3 years after graduation. The average starting salary of M.S. graduates needs to be more than that for B.S. students. The demand of M.S. graduates is often assessed from the employers. It is to be noted that if a graduate program in Engineering Technology is relatively young (less than ten years old) and the number of M.S. graduates is less than 500, the employer database might not be large. This parameter needs to be considered carefully with proper perspective for the subsequent strategic analysis and plan.

Additional factors such as career placement services for M.S. students, internship opportunities, access of the M.S. students to the department, college and University alumni network, and faculty mentorship for career placement are critical contributing factors to the strength and weakness matrix (Table 1).

f. Global experience: Global experience is and will be an important desirable skill for the future graduate students. Thus, the number of international students in a graduate program is a critical factor. Many times, international graduate students tend to congregate with the students from the same country or from the similar region. This practice does not contribute to the student's global learning experience. Therefore, well-designed provisions for interactions of the international students with domestic students can provide valuable learning experiences for the graduate students.

A variety of study abroad opportunities is available in a typical University system. Though M.S. students are eligible for such opportunities, participation in such programs is not common among graduate students. Embedding study abroad programs within a graduate program could add value and attractiveness to graduate students and their experience. Joint research or teaching collaboration with organizations or institutions outside the USA is another value added proposition for graduate education and training for M.S. students in Engineering Technology. The number of faculty and staff from international countries could also add to this factor in a positive manner.

g. Diversity: Opportunities for underrepresented students in the M.S. program in Engineering Technology is another attribute that contributes to the strength of a program. Sometimes, graduate students are also married and their decision to continue the graduate program is associated with an appropriate opportunity for their spouses.

h. Quality of life: Other factors such as the safety and security of the campus and the University, logistics and transportation, access to health care are also equally important factors affecting a student's decision to join a graduate program.

Using the above described factors, (Table 1), a numerical assessment can be made to reflect the distribution of strength and weakness (areas for improvement) for all these factors. Rating of four or higher in an attribute represents the strength and a rating below three reflects the areas for improvement. The generated assessment information can be used along with opportunities and threat to develop a strategic plan. It is also important to identify relevant constraints that might have contributed to a lower rating of the attributes and if those constraints are financial constraints, policy constraints, economical issues etc. The temporal nature of the identified constraints needs to be identified as well.

2.2.2. External Analysis – Opportunities and threats:

a. Opportunities (needs): The existing opportunities, needs and trends in the societal, economical, and global domains are analyzed in this section.

A general trend of the past B.S. graduates in discipline specific Engineering Technology indicates that many of the graduates enhanced their career with a MBA degree and have been successful in their careers. This observation is also similar to those in Engineering disciplines. B.S. graduates working for companies utilize the employer's tuition reimbursement benefit to earn a M.S. degree. Many B.S. graduates after working for 2-3 years in companies opt for an MBA or executive MBA, as a technical B.S. degree combined with an MBA creates additional career opportunities for the person. This trend creates a question for analysis – how can a M.S. degree in Engineering Technology provide a similar career enhancing option?

The demographics and the needs of the incoming graduate students (potential primary stakeholders) vary for a M.S. program in Engineering Technology (Figure 1). We can group the incoming graduate students to a M.S. in Engineering Technology into four categories. Fresh B.S. graduates with emphasis in a discipline specific Engineering Technology constitutes the first category. Some of the students join M.S. program as they did not secure the right jobs and they want to enhance their career options with an M.S. degree. Students from this first category like to continue with the M.S. as they have interests in research.

International students (from Outside USA – India, China) constitute the second category. In India, China, and Europe – a B.S. in discipline specific Engineering Technology or Technology is not offered. Rather, in these international countries, the engineering degrees and technological degrees are same. For example, the name of a B.S. degree in Electrical Engineering is also named as B.S. in Electrical Engineering and Technology. Students with degrees in Engineering or discipline specific engineering can apply for the M.S. in

Engineering Technology. Many of them prefer to obtain a professional job after their M.S. Thus, these incoming students prefer to join a reputed University whose brand name will help them getting a job after graduation.

The third category of the potential incoming graduate students to a graduate program in Engineering Technology constitutes the working professionals. Professionals with a prior B.S. degree in Engineering Technology or Technology explore graduate program to enhance their professional career. As mentioned above, some of them opt for Management related graduate degrees. Some of them want to obtain a M.S. in Engineering Technology with an intention to expand their technical expertise in a specific sub-discipline related to their interest or career growth.

The final and fourth category of incoming graduate students constitutes students with other interests not mentioned above. The percentage of students that belong to this category is very low.

As we enter into the next century, we will encounter opportunities and needs in various segments of the society. The National Academy of Engineers outlined fourteen different challenges as the grand challenges in the 21st century [3, 6]. These grand challenges cover societal issues ranging from environment, water, sustainability, to energy and health care. As the baby boom generation in the USA is approaching mass scale retirement, needs and opportunities will arise for healthcare of the aging population and senior citizens. The expected growth rate in biomedical engineering areas will be very high and the job growth rate by 2018 is expected to be 72% [7, 8]. This growth rate will create new opportunities for engineering technology graduate programs with emphasis in healthcare sectors and more specifically in biomedical or healthcare engineering technology areas.

Globalization is happening fast and issues related to healthcare, sustainability and food security need innovative solutions at the regional, national and global scale [9]. At the same time, strong needs for linking innovation and entrepreneurship to solve these societal and global issues will increase [10]. These needs create additional opportunities for the graduate programs in Engineering Technology and other discipline specific Engineering Technology.

With the introduction of new law(s)/policies related to intellectual property in the USA and an emphasis on boosting the economy based on technological development as well as innovation, we will observe growing needs for professionals skilled in technology management, innovation management, intellectual property management, entrepreneurship, technology transfer and product and process management. A report from Council of Graduate Schools also indicates the new direction of using professional masters programs and the “plus” component. The “plus” component could be a ten-week-end certificate program in specific areas or interdisciplinary skill modules. These

opportunities will create pathways for developing new graduate programs in Engineering Technology or related areas [13].

b. Threats: The perception and value of a graduate program in Engineering Technology by potential stakeholders (employer, students, and parents) as compared to those of a graduate program in Engineering or discipline specific engineering is one of the threats. This needs to be addressed with planning and strategy. The engineering graduate programs and MBA programs are competitors to the graduate programs in Engineering Technology.

Typically, the graduate programs in the United States University system have relied largely on international graduate students, especially from India, China and other parts of the world. With the rising economic conditions in China, and India, the students are exploring immediate job opportunities without pursuing graduate program in the U.S. Universities. Moreover, a majority of international students from top-tier institutions will opt from M.S. in Engineering or Business degrees. Thus, the access to a pool of well-prepared potential international graduate students will be more difficult by the graduate programs in Engineering Technology. Lack of access to students with strong research aptitude and academic preparation will affect the capability of faculty in Technology to build a strong externally funded research program. This, in turn, will affect the extramural grant funding to support the salary and tuition of graduate students and thus, will affect the size of the graduate program. Thus, careful strategic planning is needed to address this issue.

With the current situations of the global economy, the Universities and the academic units associated with the graduate programs need to secure additional resources from extramural sources to support graduate student and graduate research activities. This will warrant new challenges for the faculty and the associated academic leaders to enhance new avenues for additional funding.

3. General strategic recommendations:

Based on the above general analysis, the following strategic recommendation is developed.

a. Graduate programs in Engineering Technology and discipline-linked Engineering Technology have many new opportunities to explore and utilize the emerging sub-disciplines such as innovation, technical management, technology transfer and entrepreneurship. For example, a M.S. degree in Engineering Technology can explore a minor or certificate program in innovation, technology management or entrepreneurship. It is also possible to develop graduate programs in specific societal issue areas such as energy management and sustainability, where engineering principles can be used in a more applied manner.

b. Every program might consider conducting an individualized strategic analysis for its own program. Based on the analysis, each program can be strategically positioned to enhance its strength and explore opportunities. It is also important to develop collaborative partnership with other graduate programs such as business and engineering to reduce competition.

c. In a university, most of the graduate programs emphasize on the "recruitment to graduation" concept. Placement after graduation and the nature of the jobs the graduate students secure also contribute to the strength of the graduate program. Thus, the author recommends adopting "recruitment to placement" strategy instead of using the current model of "recruitment to graduation".

d. It is recommended to develop a large-scale coordinated effort to enhance the perception of Engineering Technology graduate programs by other stakeholders (employers, students, parents and other academic programs). As a part of this, it is critical to develop professional relationships with Engineering and other applied engineering professions (i.e. Biological Engineering, Society of Automotive Engineering, Chemical Engineering, and Biotechnology). Figure 2 depicts the author's perspective of the complementary characteristics of Engineering and Engineering Technology in a typical industrial value chain. This approach does not differentiate Engineering and Engineering Technology rather helps us to identify their similarities.

e. Ph.D. programs in Engineering Technology need additional separate analysis to develop strategic pathways for growth. At present, only a few of the programs offer the Ph.D. in Technology or related area (technological Innovation and management). There is opportunity in developing Ph.D. programs in emerging areas (Technological Policy, Technological Management and Entrepreneurship etc.). In addition, developing creative pathways to offer joint PhD. programs with other interdisciplinary programs such as healthcare, gerontology, energy management, innovation etc. will add value to the doctoral program and will be appealing to the students as well as the employers. A reputed university has followed this path of integrating interdisciplinary contents in graduate programs [(4)].

4. Summary and conclusion:

This paper summarizes the strategic analysis of typical graduate programs in Engineering Technology and other discipline-linked Engineering Technology programs. The author adopted a systems approach for this analysis. However, since strategic analysis can be very involved, this paper summarizes a few of the strategic recommendations for the growth of a typical graduate program in Engineering Technology or discipline specific

Engineering Technology. This analysis can be adapted for any specific program to further develop a strategic plan for a graduate program (M.S.) in Engineering Technology.

Future work will involve conducting case studies for this strategic analysis for several (3-4) graduate programs in Engineering Technology or discipline-linked Engineering Technology.

Table 1. Factors that represent strength and weakness of a typical graduate program (M.S.).

Factors	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Undergraduate program					
Reputation (overall ranking) a. University b. College c. Department					
Resources and infrastructure a. University level b. College level c. Department level					
Financial aids a. Number of fellowships for M.S. students b. Number of Teaching assistants for M.S. students c. Number of Research Assistants for M.S. students d. Other types of financial aids for M.S. students e. Percentage of students who obtain financial aid					
Marketability and post-graduate employment assistance a. Career placement service b. Internship opportunity assistance for M.S. students c. Campus recruitment for M.S. students d. Access of M.S. students to department, college and University alumni network. e. Number of graduate alumni of the program f. Number of students (gainfully employed) within six months after graduation g. Average salary of M.S. students h. Faculty mentorship for career placement					
Global Experience a. Number of international students in the program with provision for cross-interactions b. Study abroad opportunities c. Outside USA program collaborations d. International faculty and staff					

Table 1. Factors that represent strength and weakness of a typical graduate program (M.S.) – (continued)

Factors	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)
Graduate program a. Number of graduate courses available or access to other graduate courses in the University b. Access to other career enhancing options i.e. minor, certificate courses c. Offering of courses in alternate format i.e. distance education, web-based delivery d. Size of the graduate program (MS)					
Diversity a. Opportunity for underrepresented graduate students b. Opportunities for spouses of married graduate students					
Cost of education a. Tuition cost for M.S. program – local b. Tuition cost for M.S. program – out-of-state c. Tuition cost for M.S. program-international d. Cost-of-living					
Quality of life a. Safety and security b. Logistics and transportation c. Education for young children – for married graduate students d. Healthcare facilities					

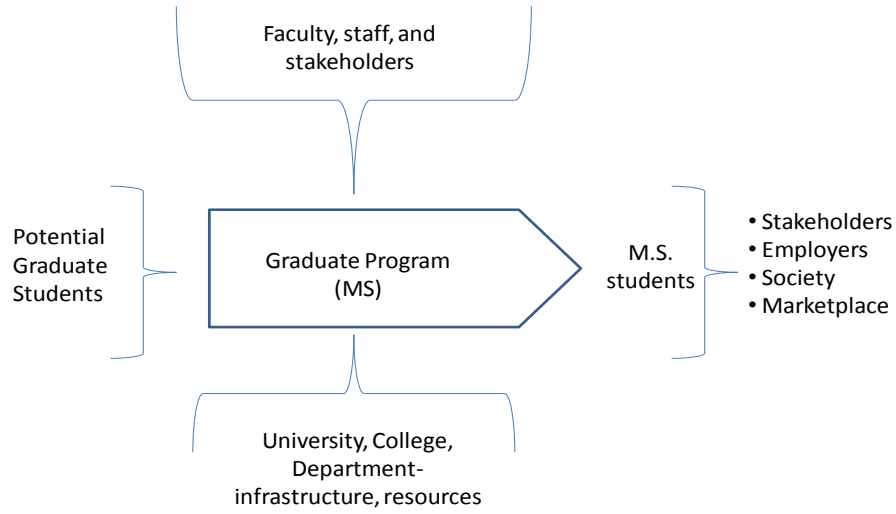

Figure 1. Perspective of a typical graduate program as applied to Engineering Technology.

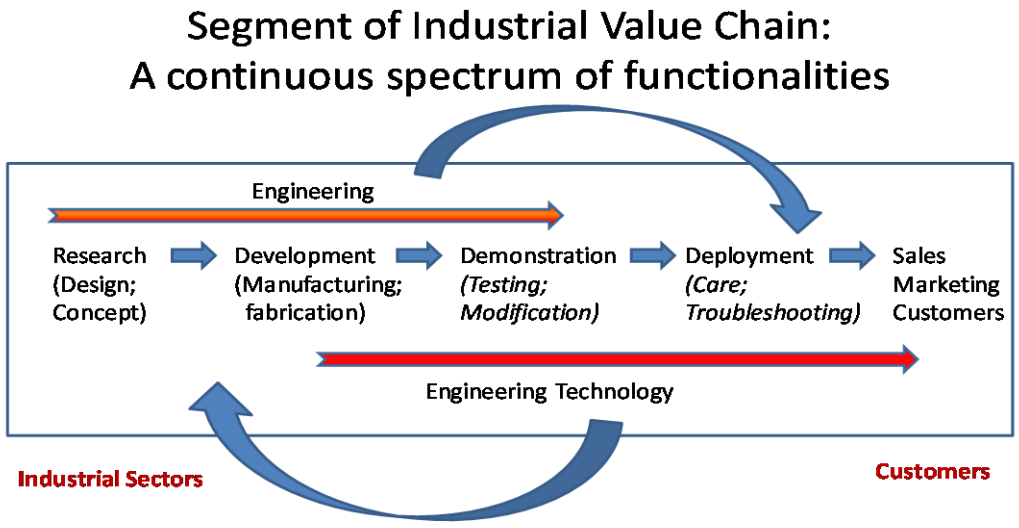

Figure 2. Perspective linking engineering and engineering technology in a typical industrial value chain.

References:

1. www. abet.org. Accessed January 11, 2012.

2. http://www.gradschools.com/program-details/carnegie-mellon-university/engineering-and-technology-innovation-management-209964_1. Accessed January 11, 2011.

3. http://www.meteconline.org/resources/papers/JET%20Final%20Paper-Future%20of%20Mfg%20ET-2002.pdf. Accessed Jan 11, 2011.

4. Rethinking graduate education. http://chronicle.com/campusViewpointArticle/Rethinking-Graduate-Education/49/. Accessed January 11, 2012.

5. Aaker, D. 2001. Strategic Market Management. John Wiley & Sons. NY.

6. Grand challenges for Engineers. www.engineeringchallnges.org. Accessed January 12, 2012.

7. http://www.biomedscientistsjobs.come.booming-biomedical-careers. Accessed January August 8, 2011.

8. http://www.aimbe.org/2011/07/careers-in-biomedical-engineering/ Accessed on August 8, 2011.

9. Grand Challenges in Global health. http://www.grandchallenges.org/Pages/Default.aspx. Accessed on January 12, 2012.

10. Kauffman thought book 2009. 2009. Kauffman foundation. Kansas city, Missouri.

11. Spicer, D., P. DeBlois and the EDUCAUSE current issue committee. 2004. Current IT issues: 2004. Educause Review 39(3). www.educause.edu/pub/er/erm04/erm043.asp. Accessed February 22, 2012.

12. Anonymous. 2006. SWOT analysis resource page. Idaho State University. www.isu.edu/acadaff/swot/index.shtml. Accessed March 3, 2012.

13. Council of graduate schools. 2006. Graduate students in 2020: new perspectives. A CGS/NSF workshop. Communicator 39(6). July.