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Envisioning Change and Revitalization for a University Engineering Management Program*

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The University of Arkansas is restructuring the Master's of Science degree in Engineering Management offered within the Industrial Engineering department. A comparison study and market survey are used to identify critical characteristics of an Engineering Management (EM) program. The comparison study analyzes 17 graduate EM programs from across the United States to discern consistencies in core courses, degree hour requirements, program course content, and availability of degree program to off-campus students. The market study survey is administered to determine the critical mass for an EM program, and recognizes potentially significant sources of student populations based on local, regional and national markets.

INTRODUCTION

IN TODAY'S engineering education environment there is a substantial need for continued growth, delivery, and promotion of the Engineering Management (EM) program across the country [1]. Regardless of whether the program mission is to reach local, regional, or national audiences, engineering professionals across multiple disciplines and industries are expressing an increased interest for further education in the area of EM [2]. While most are seeking EM graduate degrees to compliment existing engineering education and experience, some are seeking certification in specific areas of engineering management for professional developmental hour (PDH) training towards engineering registration renewal. Whether it's PDH training or traditional graduate programs, the EM discipline has the opportunity to meet the changing instructional needs of the engineering professional.

The Department of Industrial Engineering (IE) at the University of Arkansas (U-A) realizes the need for change. The IE department is in the process of restructuring an existing Master's of Science in Engineering degree with emphasis in Engineering Management (MSE-EM) to form a new Master's of Science in Engineering Management (EMGT) graduate program. Evaluation is currently under way to integrate the MSE-EM program with the existing Master's of Science in Operations Management (OMGT) program. The merge of these two programs will form a new EMGT program allowing the delivery to be offered both on campus in the traditional classroom environment and off campus as part of the College of Engineering distance education program.

The existing OMGT program is largely an off-campus distance education program primarily meeting the needs of military personnel stationed in areas where graduate education is not available. The OMGT program is open to candidates regardless of undergraduate major. In contrast, the EMGT degree will be aimed at individuals holding a Bachelor's of Science (BS) degree in any discipline of engineering or sciences. The EMGT degree will allow engineers and scientists to develop skills in the management discipline, a subject area that usually isn't incorporated into the BS in engineering or science degrees [3–5]. By having the EMGT degree offered in conjunction with the OMGT degree, well-established resources from the OMGT program can be more fully utilized. Many of the courses that exist in the current OMGT program can be included in the EMGT program without the need to convert new courses to multimedia.

PREVIOUS RESEARCH

The next logical step in the development of the EMGT program would be to review the literature to see if information is available on EM program content and structure. Research literature over the past decade yields limited information on how to identify specific characteristics of an EM program. One recent article provides a detailed study on how

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EM and Management of Technology (MOT) programs are designed based on various schools of thought [6]. According to Hicks *et al*., there are three concentration areas of an EM or MOT program. These are [6]:

- management process/empirical;
- human behavior/social systems;
- mathematical/decision theory.

The results of the study indicates that, on average, 40% of the courses are in the management process/empirical area, 17% in the human behavior/social systems area, and 43% in the mathematical/decision theory area.

An ongoing longitudinal study by Portland State University (PSU) discusses trends in EM and MOT education and research [7]. The study shows that there are seven subsystems within the Engineering and Technology Management (ETM) program structure. These subsystems are:

- innovative
- human
- organizational
- project/program
- resource
- implementation
- strategy and policy.

Nambisan and Wilemon report that the majority of the 123 MOT programs surveyed contain two general areas of study [8]. There is a management area identifying strategic management, finance, marketing, human resources, business law, and project management as core courses. The second area is technology citing strategic technology, technology entrepreneurship, technology policy and innovation, product development, and manufacturing strategy as a core set of courses.

The research by Farr and Bowman identifies a set of characteristics that an engineering manager possesses across multiple disciplines [9]. The engineering manager must possess skill-sets in traditional engineering concepts, management, leadership development, and entrepreneurship. All of these skills are used as enablers to interact with the technology, financial, people, and time perspectives in an organization.

According to earlier research, the EMGT program infrastructure can be grouped into three dimensions of Engineering, Technology and Management. Two additional dimensions of Target Audience and Continuing Education are added to address critical needs when developing a new EM program. Figure 1 shows how the dimensions and attributes for the new EMGT program are developed based on three areas of contribution.

The term dimension is used to normalize the various types of structures discussed in the research literature. Figure 2 shows how the dimensions are derived using structures defined in the research literature. The next level of stratification down from the dimension level is the attributes. The attributes describe the characteristics of a particular dimension. An attribute describes the characteristics of the dimension. The individual course offerings, core course requirements, hour requirements, professional development training hours, and delivery mechanism are considered the attributes of the EMGT program.

METHODOLOGY

In order to identify the attributes of the new EMGT program a comparison study of other EM programs is necessary. In all, seventeen programs are evaluated and the results are compiled. These programs vary in their size and scope, but the criteria for selecting the EM programs are based on geographic and demographic region, mission of the institution, state support, and engineering-based degrees. The Internet is used to collect data about the selected EM programs. Several

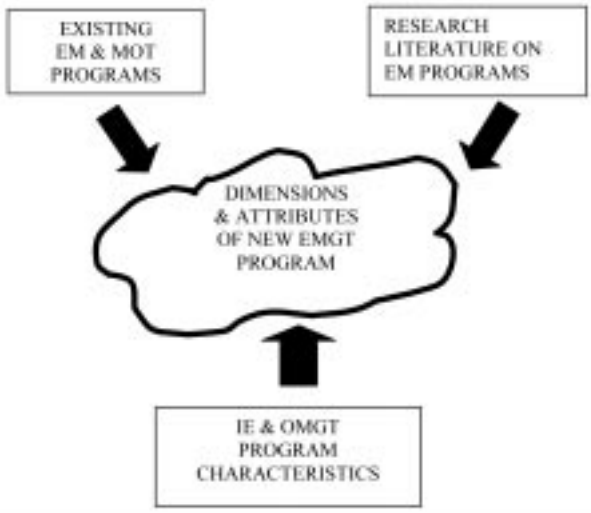

Fig. 1. Three areas of contribution in developing the EMGT program.

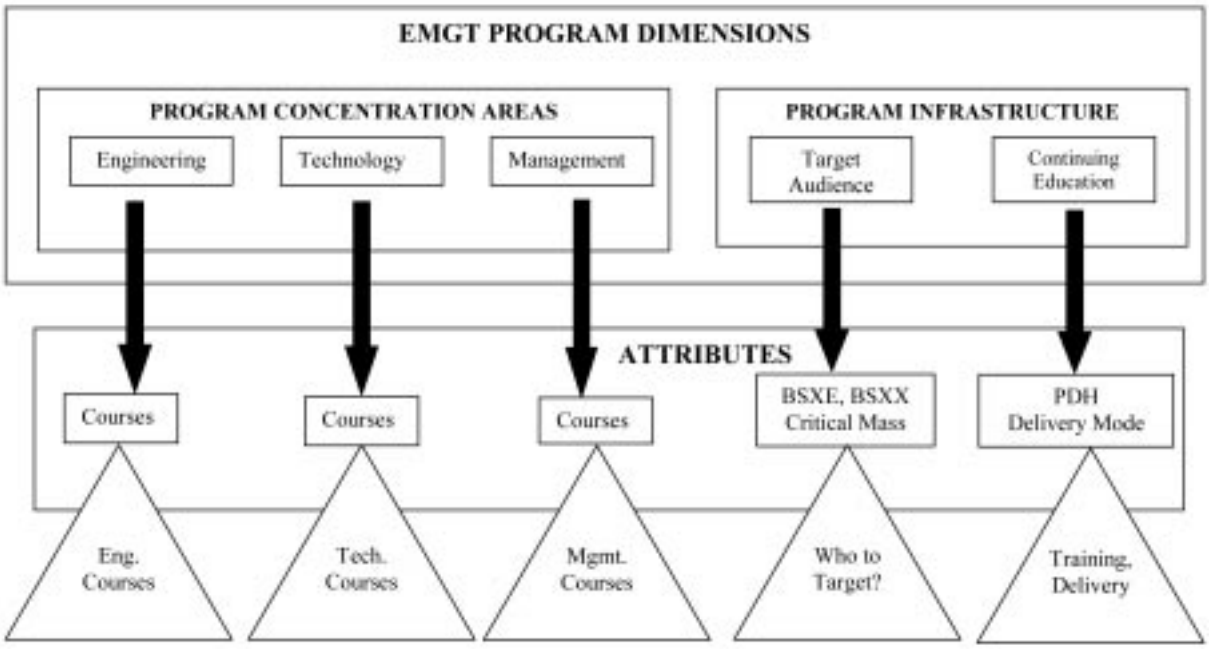

Fig. 2. Dimensions and attributes for the EMGT program.

'critical' attributes are considered for this comparison study. For each attribute a question must be answered:

- *Course offerings*—Does the OMGT and IE programs offer courses comparable to other Engineering Management programs?
- *Core courses*—Should a certain number of core courses be required?
- *Hour requirements*—What is the typical number of hours required for this type of degree?
- *Thesis or capstone project*—Should a thesis or capstone project be required of degree candidates?
- *Target audience*—Who is the target audience and what criteria should they meet?
- *Delivery mechanism*—Is the degree also available through distance education?
- *Professional developmental hours*—Do programs offer training and certification for professional development hours? What would be a mechanism to deliver PDH training to the engineering professional?

	Florida Institute of Technology	Florida International University	George Washington University	Oklahoma State University	Portland State University	Southern Methodist University	Texas Tech University	University of Massachusetts	University of Michigan – Dearborn	University of Minnesota – Duluth	University of Missouri – Rolla	University of South Florida	University of Tennessee – Chattanooga	University of Tennessee Space Institute	University of Texas at Arlington	University of Wisconsin - Madison	Vanderbilt University
number of hours	36	36	36	32	52	30	36	36	36	30	30	36	36	33	36	30	30
#of core hours	0	24	21	26	28	21	15	18	30	15	0	21	12	21	30	30	18
thesis required?	n	n	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n
capstone project?	n	y	n	y	y	n	n	n	n	y	n	n	n	y	n	n	y
distance education?	n	n	y	y	y	n	y	y	n	n	y	y	n	y	n	y	n
require experience?	n	n	y	y	n	n	n	n	y	n	n	y	n	y	y	y	n

Fig. 3. Comparison of program details.

COMPARISON STUDY ANALYSIS AND RESULTS

The EM programs examined varied significantly in their actual degree requirements. The required number of hours typically ranged from 30–36, except for PSU which requires 52 hours; however, they utilize a quarter-system rather than the semester-system in place at the other programs evaluated. The number of core courses required for graduation also varied. A few of the programs did not include a core curriculum, giving students a wide breadth of options, while others offered little to no alternatives with electives. This information is presented in Fig. 3 for reference. Several of the programs examined offer a thesis-option, but Portland State University is the only one to require a thesis. Industry-related capstone projects are also an option at some of the programs evaluated. Typically these capstone projects are aimed more for students enrolled in an on-campus, rather than off-campus program.

Course offerings

The significant attributes within the Engineering, Technology and Management dimensions are the various course offerings. Course offerings are identified in each EM program, along with the overall admission standards and program structures of programs. Course names varied from one institution to another, so catalog descriptions are used to find courses that appeared similar in nature, then the most commonly used course name is used in the comparison.

Shown in Fig. 4 are many of the courses offered in the compared programs. In programs where core courses are required, these are noted with an 'r' and the others with an 'e' indicating that it is an elective. In programs where there is no core curriculum, all courses are indicated with an 'x.' Also shown in the table is the total number of compared programs that offer each particular course. The shaded courses in Fig. 4 indicate the most popular core courses for other EM programs.

Figure 5 provides a comparison between courses in the surveyed EM programs and the offerings in the IE and OMGT programs. As this Figure illustrates the program is dominated by engineering courses, but there are eight courses in management and three in technology dimensions that would allow engineering professional to acquire knowledge in these important areas. The technology dimension will need the most course development as there are no support courses from the IE or OMGT programs that could be cross-listed as EMGT courses. Courses such as engineering accounting and finance, information systems, and legal systems would need to be developed for the new EMGT program.

Target audience

When evaluating the data for the target audience several issues are raised. First, the compared programs would provide information on the requirement for an undergraduate engineering degree. Secondly, it is investigated whether other programs required engineering work experience as a prerequisite to admission into the program. And third, from a different perspective, there is a need to determine a critical mass of the target audience.

The majority of the compared programs require an engineering degree for admission, with a few allowing hard science and math degrees. There appears to be no difference in admission requirements for on-and off-campus Engineering Management degrees. However, this is not the case for the experience requirements. Slightly more than half of the programs that offer distance education degrees require work experience, but only one of the traditional programs require it.

Delivery mechanism

The OMGT program currently provides live instruction and video taped courses at the remote sites to give flexibility of delivery to the students. With the anticipated co-offering of the EMGT and OMGT programs this format for program delivery is expected to continue unchanged. In support of the OMGT delivery format, approximately half of the compared programs indicated a similar format for delivering the program.

Further research will be necessary to identify the most appropriate mode of distance education delivery. A comparison between videotape, CD/DVD, video conferencing, and streaming video methods will determine the best delivery format for the EMGT and OMGT programs. The objective of the study will be to identify the most efficient and cost effective delivery mechanism for distance education.

Professional development hour training

Professional engineering registration in some States require continued training and development in engineering education [10]. Even though the number of professional development hours (PDH) is somewhat a dynamic number, there is an estimated three million PDH training hour requirements per year for U.S. licensed engineers [11]. Whether it's a one-hour training module or an 18-hour certificate, there is an opportunity for the EMGT program to benefit significantly by providing a service to the engineering professional by delivering training modules to participants.

Referring back to the target audiences, both local and national engineers indicated interest in an EMGT program. As a result, the IE department is investigating the potential of offering training modules in project management, engineering management, advanced economic analysis, and decision theory to all engineers. To add breath and depth to the PDH training program, the Colleges of Engineering and Business plan to

	Florida Institute of Technology	Florida International University	George Washington University	Oklahoma State University	Portland State University	Southern Methodist University	Texas Tech University	University of Massachusetts	University of Michigan – Dearborn	University of Minnesota – Duluth	University of Missouri – Rolla	University of South Florida	University of Tennessee – Chattanooga	University of Tennessee Space Institute	University of Texas at Arlington	University of Wisconsin - Madison	Vanderbilt University	**Total**
Advanced Engineering Economics			r		r			r			x		r	r	r	r		**8**
Benchmarking Practices				x				e										**2**
Cost Accounting and Decision Making											x							**1**
Decision Making/Theory			r	x	r	r	r	r			x	e						**8**
Design of Experiments				x	e		e							e			x	**5**
Engineering Accounting & Finance		r				r			r	e	x			e	r			**7**
Engineering Management		r	r		r	r	r		r	r	x	r	r	r	r		x	**13**
Engineering Modeling/Design	x																	**1**
Entrepreneurship					e	e					x	e	e				x	**6**
Human Factors/Industrial Psychology								r				e		e				**3**
Human/Labor Relations											x	e		e				**3**
Information Systems		r		x					r	e	x	e		e	r	r		**9**
Legal Aspects of Engineering				x	e			r	r	e	x	e	e					**8**
Logistics	x							e										**2**
Marketing	x	e			r				r	e		e					x	**7**
Optimization					r		r	e				r	e	r				**6**
Organizational Behavior		e	r						r									**3**
Organizational Theory & Strategy		e			e													**2**
Performance/Production Management				x	r	r	e	e	r		x	r		e	r			**10**
Probability/Statistics						r		r				r		r		r		**5**
Product Development	x	e			e				e				e					**5**
Production, Planning and Control		e		x	e							e			e			**5**
Project Management	x	r	r	x	r					r	x	e	e	r		r	x	**12**
Reliability/Quality Engineering	x			x				r			x	e	e	e		r	x	**9**
Safety							e				x	e		e				**4**
Simulation					e		r							e				**3**
Systems Engineering	x		r		e				r									**4**
Technical Management			r						r			e	e	e	r		x	**7**
Technology Commercialization			e		e							e					x	**4**
Total Quality Management		r		x	e		r		r	r	x			e			x	**9**

Fig. 4. Course offerings.

work collaboratively with the IE department to develop and deliver the training modules.

In addition, certificates are already being offered in the OMGT program. The certificate requires eighteen hours of coursework in a concentrated area. Similar certificates for the EMGT program will be available to students who wish to focus on a particular aspect of the engineering management discipline such as project management, systems engineering, financial engineering, etc.

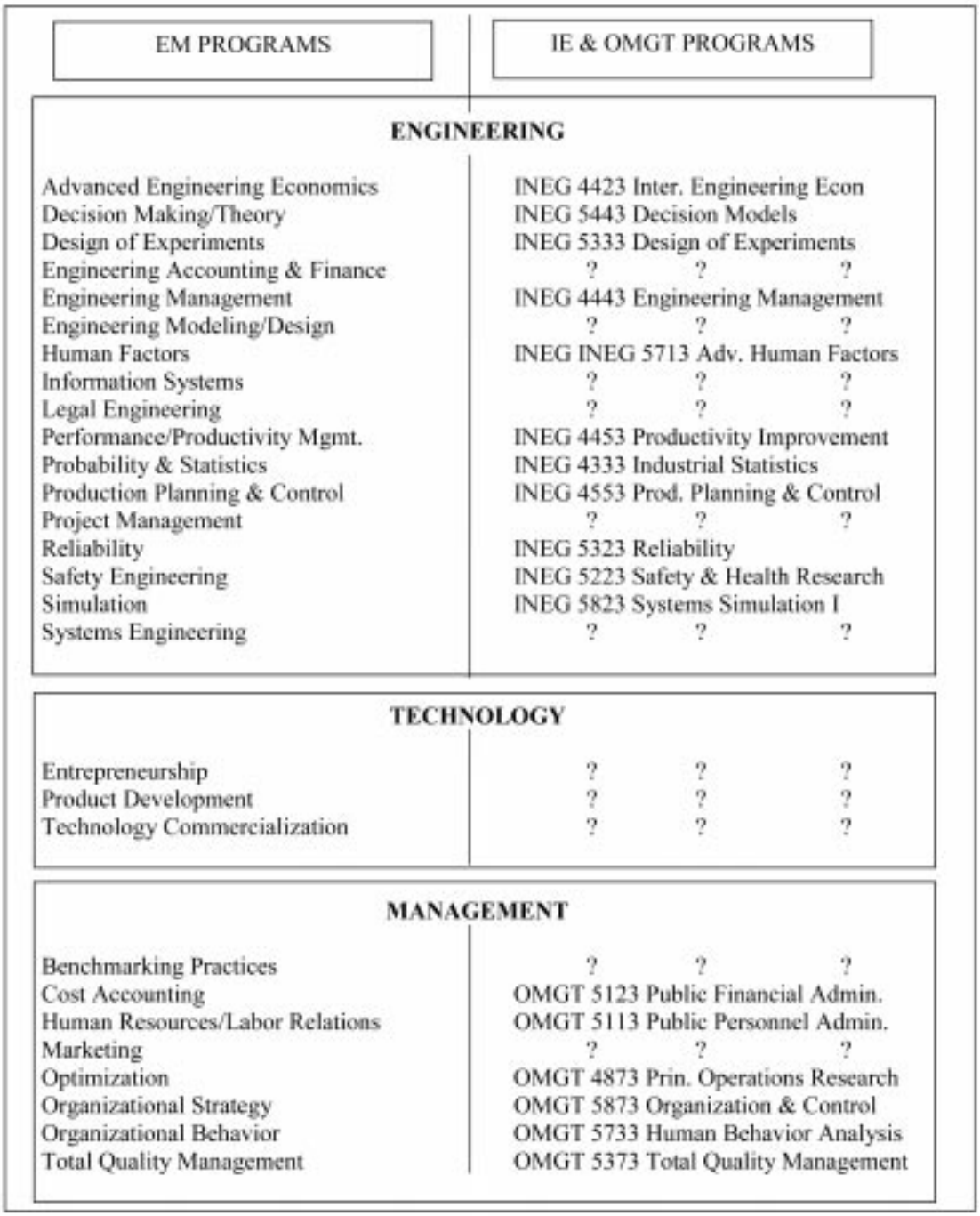

Fig. 5. Comparison study by dimension.

MARKET STUDY SURVEY

The third issue for the target audience is the most difficult to determine. Only an estimated five percent of the recent U-A Engineering graduates indicated an interest in an EMGT graduate degree, so other sources of students are necessary to sustain enrollment in the program. Therefore, a market study is administered to identify levels of interest in the EMGT program externally. To help gather this data, a telephone survey of forty-seven companies who currently employ U-A engineering graduates is conducted. The IE alumni is contacted at the selected companies, and given an outline of the prospective EMGT program. To conclude the telephone interview the survey participant is asked a standardized list of questions regarding both the employees' and the companies' desire for such a program. Three specific questions are:

- *Approximately how many engineers with Bachelor's degrees does the company employ?*
- *What percentage of these engineers would be interested in this type of Masters program?*
- *Does the company pay for continuing education?*

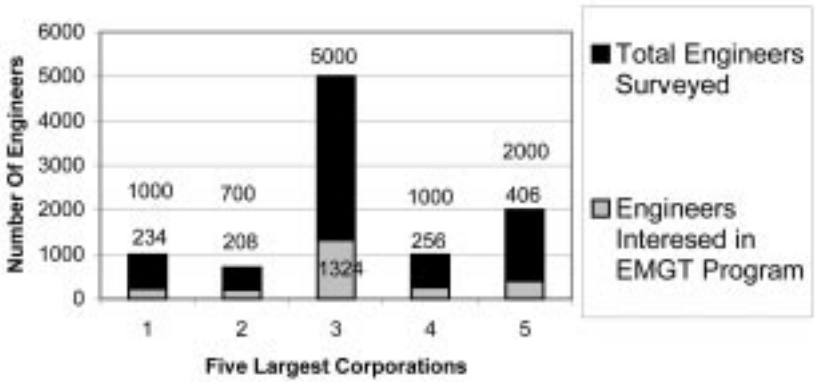

Fig. 6. Number of engineers interested from large national companies.

If the interviewee expressed interest in the EMGT program, the interviewer then sent the company an information packet to review. Since the survey participants are IE Alumni, companies from across the United States represent the study population. However, the majority of the survey participants were located in close proximity to one of the OMGT remote site locations. This sampling strategy worked well for the study since our primary interest would be to attract companies with regional ties to a remote site. In order to compare the responses of large corporations and smaller companies, the contact list included national companies, who employ thousands of engineers, and smaller companies with only one or two engineers on staff.

Fourteen of the twenty companies surveyed indicated a strong interest in a Masters of Science in Engineering Management program, with three of the companies contacted expressed disinterest and three indicated that they no longer directly employ engineers. Geographic location had no effect on the companies' interest level. Companies from around the country expressed as much interest as those did from the Arkansas region. The twenty companies surveyed collectively employ 10,215 engineers. Of these engineers, 2503 (24.5%) expressed interest in the EMGT program. The five largest companies surveyed employ a total of 9700 engineers. Ninety-seven percent of the engineers interested in the EMGT program (2428 engineers) are employees of these large companies. The remaining 75 engineers represented the small regional companies. Figures 6 and 7 show graphically the breakout of the interested Engineers from the large and small companies. All of the companies contacted pay for part or all of their employee's continuing education.

The results of the market study identified two additional areas that would provide students for the program. Small local companies indicated an interest in advanced education in engineering management for their engineering employees. The number of potential students from these companies would be steady with 3–4 students per company each year being predicted. Collectively, this would certainly provide critical mass with the continued growth and development of the Northwest Arkansas region, and current U-A engineering undergraduates interested in the EMGT graduate degree.

Possibly of greater importance to the program is the significant number of engineers that are available from the large national companies. It was determined from the market study that approximately 25% of the employed engineers in these companies would be interested in an EMGT degree. An eligible number of engineers in these

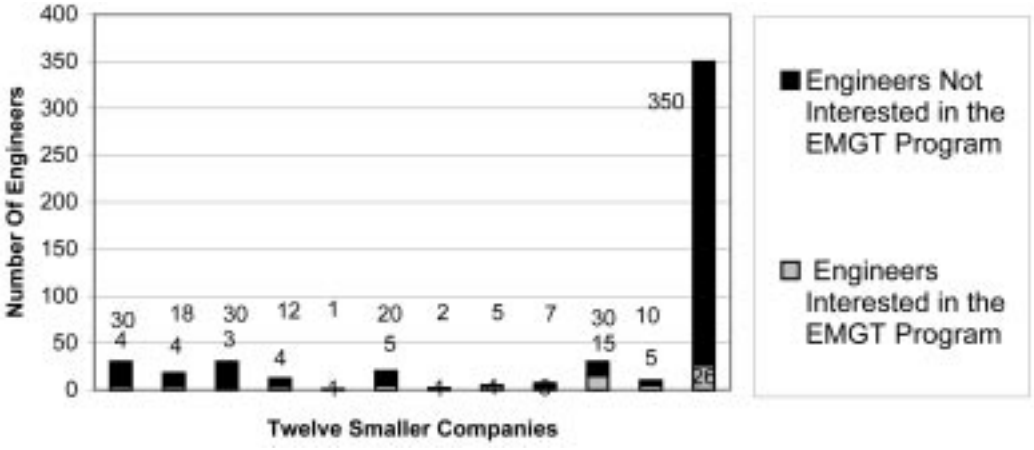

Fig. 7. Number of engineers interested from small regional companies.

companies ranged from 200 to 1000 dependent upon the size of the company. All of the companies interviewed had continuing education programs which paid for courses towards certification and graduate degrees. This would be a major consideration when contacting a participating company to enroll students into the EM program.

CONCLUSIONS

In conclusion, the comparison and market studies are able to develop critical dimensions and attributes of an EMGT program. Based on the results of the study the number of hours required for the EMGT degree are 30 hours for the thesis option, and 36 hours required for the non-thesis EMGT degree. The thesis option allowed 24 lecture hours and six hours for thesis research. The non-thesis option is 36 lecture hours and is the most popular plan of study format for distance education students.

The most common set of core courses are identified to give students a concentrated focus in engineering management, and yet provide an acceptable level of flexibility in course offerings to complete the remaining hours for the graduate degree. The most popular core courses are:

- Advanced Engineering Ecomony
- Decision Making/Theory
- Engineering Management
- Performance/Production Management
- Project Management
- Probability & Statistics

The target audience required careful evaluation and attention as the EMGT program would have to differ in the application requirements from the OMGT program. The OMGT program allows all degrees to be admitted into the program with consideration towards meeting the requirements of deficiency courses. In contrast, the EMGT program would require all entering students to have some form of 'BSXE' engineering degree, or 'BSXX' degree in a hard science discipline. Engineering work experience is considered by some EM programs to be a requirement for entrance into the program, but it will not be required for the U-A EMGT program.

Another important aspect of restructuring the EMGT graduate program is where to recruit potential students. The market study survey identified the critical mass for the program as the small to medium companies based locally to the U-A, as well as, undergraduate engineering students continuing their education before entering the job market. Significantly greater numbers of student 'pockets' are located in the larger national companies which are more reachable by the distance education EMGT program.

The delivery method for the distance education portion of the EMGT program will continue to be videotape based for now. Evaluations are underway to recommend the most cost-effective method to deliver the highest quality media to the student using the newest technology available.

Finally, one added feature of the new and restructured U-A EMGT program is the instructional support for professional development hours to state registered engineers. Each compared EM program was unique in some way, but all had the capability to provide specialized training to fulfill the yearly requirement of continued training for engineers. The U-A plans to offer certificates in several engineering management areas that would suffice as development hours.

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