

## **2006-1707: DEVELOPMENT OF A NEW INTEGRATED ENGINEERING PROGRAM**

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# Development of a New Integrated Engineering Program

## Abstract

A new four-year, integrated engineering program has been developed, from scratch, at Southern Utah University (SUU). This program, which consists of a combination of several disciplines, is in its sixth-year of implementation and has been highly successful. This paper discusses in great depth this unique program. It shares the knowledge and experiences gained and the lessons learned from developing this program, implementing it, and preparing it for and leading it to ABET accreditation. Several aspects of the program are discussed, including the need for it, the composition of the curriculum, preparation for the ABET visit, the competency and success of the first graduates, and how the program is viewed by the students, the local and regional industry, and the community.

## I. Introduction

Over the past few years, engineering education has been the focus of numerous studies and discussions<sup>1-8</sup>. What sparked renewed interest in this issue is the need to enhance the first-year experience of engineering students and to address the growing demand for engineers and scientists capable of thinking and functioning across disciplines and beyond, in a workplace and a society that are rapidly changing due to the emergence of new technologies and several other factors. Numerous studies<sup>3,8</sup> have shown that retention of engineering students is greatly affected by the experiences lived by these students in their freshman year and, to a lesser extent, in their sophomore year. This prompted several universities across the nation to devote a great deal of effort and energy into the development of new and meaningful ways of delivering education at the freshman level. In addition, the National Science Foundation (NSF) has recently sponsored a coalition of universities, including Arizona State University, Rose-Hulman Institute of Technology, Texas A&M University, the University of Alabama, the University of Massachusetts at Dartmouth, and the University of Wisconsin at Madison. Each of these institutions was charged with developing innovative curricula in an effort to enhance the experiences of students at the freshman and sophomore levels in an attempt to increase students' interest in the science and engineering fields and improve retention beyond the sophomore year. One of the most reported curricular changes involves the careful integration of several courses within the discipline and across several disciplines. This was prompted mainly by the belief that students' understanding of the subject matters and their interest in engineering are greatly improved once they realize why the courses are important and how they are related to each other. The Integrated Engineering program introduced at Southern Utah University is based upon a different philosophy and was developed for entirely different reasons than what is mentioned above. To understand the rationale behind this program, a review of some of the circumstances that led to its creation follows.

## II. Rationale Behind the Integrated Engineering Program

As mentioned earlier, there are several reasons that led to the creation of the Integrated Engineering program at Southern Utah University:

1. according to the Utah Manufacturing Extension Partnership (UMEP), the majority (99.2%) of manufacturing companies in the state of Utah are classified as small companies (less than 500 employees). Figure 1 shows the distribution of Utah manufacturers by size. It is noteworthy that about 75% of all manufacturers have less than 50 employees, of which less than 2% hold a four-year degree in engineering. For these companies it is not economically feasible to hire a team of specialized engineers. Therefore, these companies are better served by engineers with a broader background and capable of functioning effectively in a multidisciplinary environment. The Integrated Engineering program was developed to meet the need these companies have for engineers with such a background and training;
2. a critical shortage of engineers in the state of Utah prompted former Governor Leavitt, in 2000, to create the Engineering Initiative which provided funding for school to develop new ways of increasing the number of engineering graduates in Utah. The objective of this initiative called for tripling the number of engineering graduates by 2008. The Integrated Engineering program was created to expand the pool of engineering branches offered in Utah's schools of higher education, without duplicating any of them. It addresses the needs that are not covered by the traditional engineering programs;
3. many students are interested in a blend of engineering disciplines rather than a specific branch. This is especially true for those wanting to pursue a career in operations and/or management. Because of its multidisciplinary nature, the Integrated Engineering program addresses the needs of most of these students.

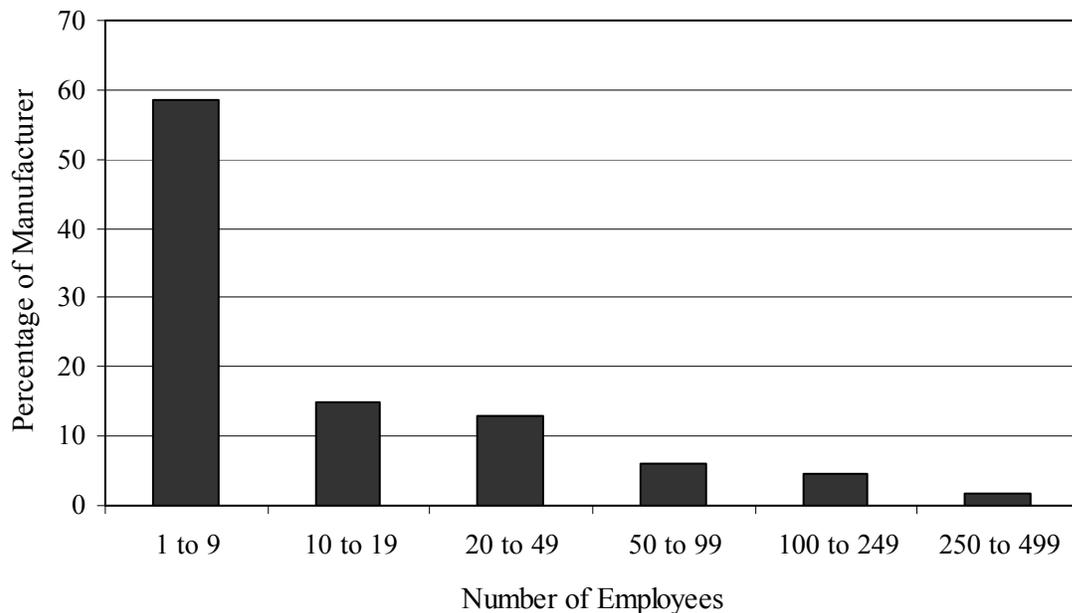


Figure 1 Utah Manufacturers by Size (Courtesy, UMEP)

### III. Development and Structure of the Integrated Engineering Program

Development of the Integrated Engineering program was initiated in 2000, with strong support from administration. In order to determine the need for this program in Utah and across the nation, and to better define its objectives, a survey was developed and sent to 500 engineering companies, most of which are in manufacturing. The reason for focusing on the manufacturing industry is because the majority of the companies in Utah are in manufacturing. The survey was accompanied by a description of the program and a cover letter. A copy of the survey is included in the appendix. The size of these companies ranges from 1 employee to 350 employees and thus, qualify as small companies. These companies are located in the states of Arizona, Colorado, Nevada, and Utah. Approximately, 62% of the companies surveyed are located in Utah. Table 1 shows the distribution of the responses received by region as well as partial results dealing with the question of whether the program should be implemented.

Table 1 Distribution of the responses received by region

Company Location	Number of surveys sent	Number of respondents	Should the program be implemented?	
			Yes	No
Arizona	52	20	19	1
Colorado	25	9	9	0
Nevada	44	17	17	0
Northern Utah	348	47	44	3
Southern Utah	31	26	24	2
Total	500	119	113	6

Although only 24% of the surveyed companies responded, the majority of the respondents (95%) recommended implementation of the program, according to the results shown in Table 1. In addition, several respondents expressed their willingness to hire graduates of the program and to participate in co-op and internship programs. Results from this survey are further supported by those obtained by the University of Western Ontario which houses a similar program. According to the results received and analyzed by the University of Western Ontario<sup>2</sup>, industry response to their Integrated Engineering program was overwhelmingly positive. In addition to industry surveys, a questionnaire was developed to get students' input in regard to their interest in the program. The questionnaire, accompanied by a description of the program, was sent to several local and regional high schools. The responses received were very positive. The most frequently cited reason for the interest of the students in the program is the fact that it allows students to get a degree in engineering without forcing them to choose a specific engineering discipline. A modified version of the questionnaire was also completed by our pre-engineering students. At the time, SUU had two-year pre-engineering programs in eight of the traditional engineering disciplines.

Armed with the overwhelming support received for the implementation of the program, and using the comments received from industry, the engineering faculty (2.5 full-time equivalent) at SUU set about developing the final form of the program educational objectives and outcomes. A

curriculum was then developed from scratch to ensure achievement of the objectives and outcomes by the graduates of the program. This curriculum was intended to satisfy the following criteria:

1. it must include a blend of courses from at least three traditional engineering disciplines. This was done to ensure that the program is truly an integrated engineering program. The three fields from which courses were selected include Civil Engineering, Electrical Engineering, and Mechanical Engineering. These fields were selected based on the survey results received from industry;
2. it must include a strong design component which provides students with exposure to contemporary engineering practices in multidisciplinary fields. In fact, it is in the design sequence that the “integrated engineering” aspects of the program is achieved by giving students the opportunity to work on projects requiring the integration of several concepts into a system or a process;
3. it must emphasize fundamentals principles;
4. it must be rich with opportunities for students to use modern engineering tools and equipment;
5. it must emphasize breadth rather than specialization;
6. it must equip the graduate with enough knowledge to solve an engineering problem, know what knowledge is required in order to solve the problem and be capable of learning the appropriate new material and applying this to the solution of the problem, or to discuss the problem intelligently with a hired consultant;
7. it must require students, through its design component, to design, build and test a system or product to satisfy an engineering need.

The Integrated Engineering program is in its 6<sup>th</sup> year of implementation and the curriculum has undergone two cycles of iteration. The curriculum is shown in Figure 2. It includes 120 credit hours. As can be seen from this figure, the curriculum is strong in the fundamentals and includes several design laboratory courses which form the backbone of the program. Furthermore, it is much broader than any of the traditional engineering programs. Graduates of the program are also required to pass the Fundamentals of Engineering (FE) exam in order to graduate.

The Integrated Engineering program produced its first graduated class (eight students) in May 2004. All of the graduates have found employment at or before graduation, with salaries ranging from \$38,000 to \$72,000. A survey of their employers, which include a variety of engineering firms and governmental agencies, indicates that these graduates have been performing beyond their employer’s expectation. Graduates of the program attribute their success to the broad, integrated engineering education they received.

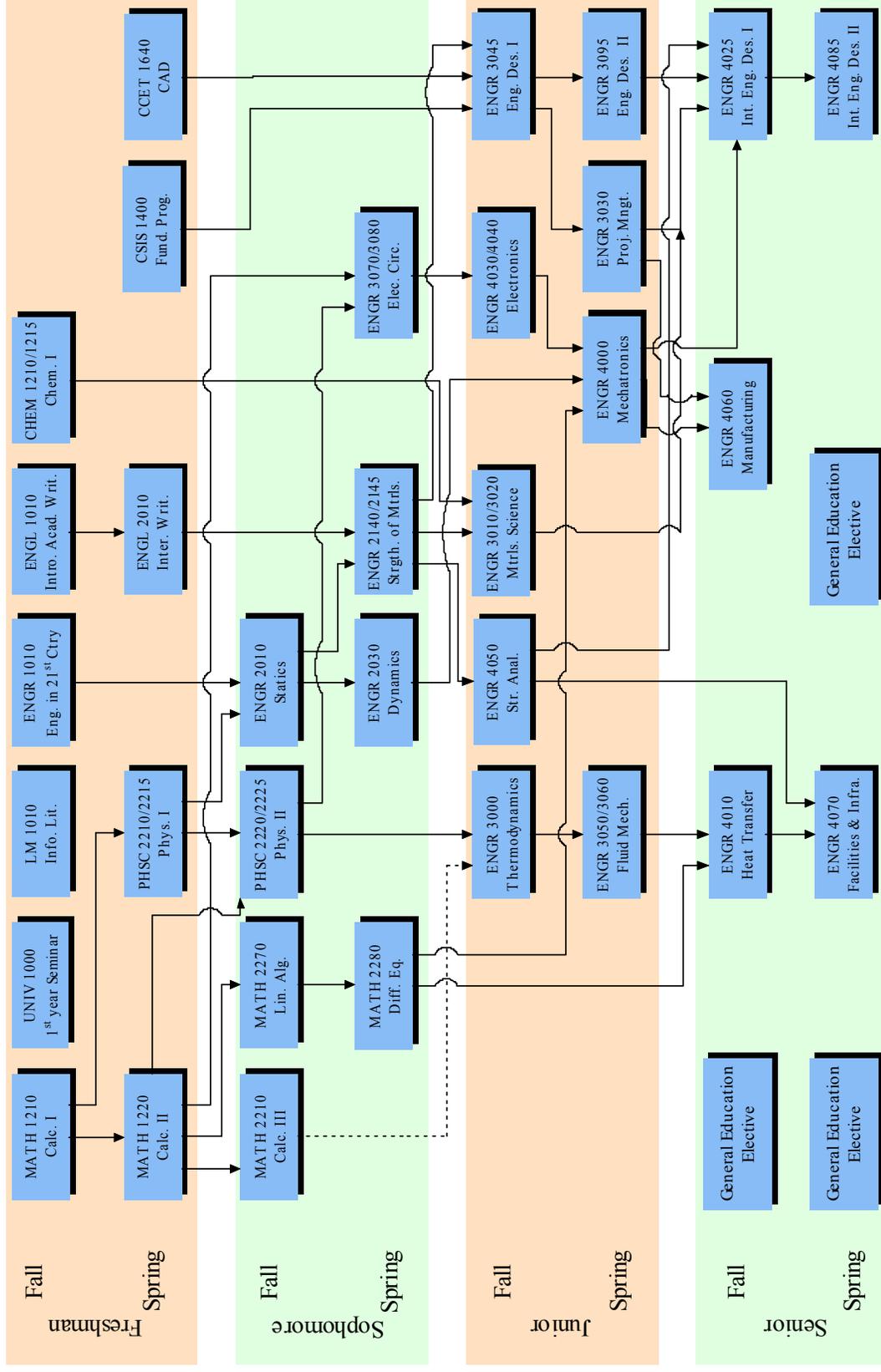


Figure 2 Integrated Engineering Program - Course Pre-Requisite Structure

#### IV. Accreditation of the Integrated Engineering Program

The Integrated Engineering program was developed from scratch and is based on input from the industry and SUU's pre-engineering students. The program educational objectives, the program outcomes, and the curriculum are also based on this input. Program assessment tools and processes consistent with ABET/EAC accreditation requirements were developed right after the program was approved by the board of regents. During the development phase of the program self-study report, several difficulties were encountered. Because this was the first time that an "Integrated Engineering" was offered, no criteria specific to this program were available in the ABET/EAC accreditation handbook and thus, the faculty did not know for sure which criteria needed to be satisfied. Second of all, in the past no faculty member had ever been involved in an ABET accreditation preparation. In addition, no funding was available to hire a consultant to help guide the faculty in the right direction. These problems gave rise to a great deal of friction between the faculty members, due to conflicting opinions. For instance, each faculty wanted to include, as much as possible, courses from his/her own discipline. Had the tension not been relieved, accreditation of the program would have been jeopardized. Numerous meetings were held to discuss the problems and to try to focus on the objectives of the program and what needs it is supposed to support, instead of letting our personal interest take us farther from the goals of the program. Despite these obstacles, preparation for the ABET accreditation visit proceeded as scheduled and the program self-study report was prepared and submitted to the ABET headquarters on time. Since the Integrated Engineering program is a brand new, non-traditional program, and because this was the first time that accreditation was requested for this program, the faculty had to come up with strong and highly convincing arguments about the viability of such a program and its overall usefulness. The ABET accreditation visit occurred in the fall of 2004. Contrary to what a few of the faculty members felt, the visiting team was highly impressed with the program, the assessment tools and processes, and with the self-study report itself. The program was granted unconditional, full accreditation status in August 2005.

Leading the program to accreditation was by no means an easy task. It required a great deal of effort, time, and sacrifice. However, preparing the program for ABET accreditation forced the faculty to learn how to interact with each other, to respect the opinion of each other, and to believe in the capabilities of each other. Accreditation of the program provided an excellent example of what can be achieved when faculty members work together in harmony and when the accreditation preparation is performed with a positive attitude toward the outcome.

#### V. Conclusions

The development of a new Integrated Engineering program has been discussed in detail. This program, which was developed from scratch, based on input from industry and students, is highly successful and received full ABET/EAC accreditation. The rate of success of the students enrolled in this program in the FE exam is 100%, which is really not surprising since this is a requirement for accreditation. All graduates of the program secured employment before graduation and their employers reported positively on their performance. Preparing the program for ABET/EAC accreditation was time-consuming and, at times, very frustrating. However, it forced the faculty to learn how to interact with and respect each other. The success of this

accreditation clearly demonstrates that a great deal can be achieved, against all odds, when a positive attitude is maintained throughout the preparation phase.

## VI. References

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# Appendix I

## Integrated Engineering Survey

### We need your help!

Based on the enclosed description, it is our belief that the proposed **Integrated Engineering** program at Southern Utah University has a lot of merit and would be very attractive to students. We are, however, sensitive to your needs and requirements. Industry can better judge its soundness and relevance to the marketplace, and can contribute the most to its creation. Since time is of the essence, we respectfully solicit your assistance to us by completing and returning the following questionnaire at your earliest convenience.

Name: \_\_\_\_\_ Total number of employees: \_\_\_\_\_  
Company: \_\_\_\_\_ Total number of engineers: \_\_\_\_\_  
Title: \_\_\_\_\_ Nature of business/industry/products manufactured: \_\_\_\_\_  
Email: \_\_\_\_\_

Please answer the following by checking the appropriate selection(s) under each question.

1. Would a multidisciplinary engineering education serve your industry's needs and requirements?  
 In most cases       In some cases       In no case
2. Do you believe an Integrated Engineering degree would directly affect any of the following for a prospective employee?

Starting Salaries	<input type="checkbox"/> More	<input type="checkbox"/> Less	<input type="checkbox"/> No Impact
On Going Pay Scales	<input type="checkbox"/> More	<input type="checkbox"/> Less	<input type="checkbox"/> No Impact
Job Assignment	<input type="checkbox"/> More	<input type="checkbox"/> Less	<input type="checkbox"/> No Impact
Management Opportunities	<input type="checkbox"/> More	<input type="checkbox"/> Less	<input type="checkbox"/> No Impact
3. Based on the enclosed description of the Integrated Engineering program, do you think that, after a suitable period of training, its graduates would perform as effectively, or more effective in your company as engineers from a more specific disciplined degree (i.e., CE, ME, EE, etc.)  
 Yes       I don't know       No
4. Do you see enough value in what has been presented to warrant our proceeding with implementation of the Integrated Engineering program?  
 Yes       No
5. Assuming that the broad-based Integrated Engineering program is implemented, please check the areas of focus that would best meet the needs of your company. (Rate all that apply – 5=Excellent, 4= Above Aver., 3= Aver, 2= Below Aver., 1=Poor/Unacceptable)

<input type="checkbox"/> Design Engineering	<input type="checkbox"/> Materials Engineering
<input type="checkbox"/> Data Analysis	<input type="checkbox"/> Facilities Engineering
<input type="checkbox"/> Quality Assurance	<input type="checkbox"/> Chemical Engineering
<input type="checkbox"/> Manufacturing Engineering	<input type="checkbox"/> Civil Engineering
<input type="checkbox"/> Process Engineering	<input type="checkbox"/> Electrical Engineering

- Mechanical Engineering
- Composite (non-metallic) Engineering
- Documentation
- Sales & Marketing
- Project Management
- RFP Prep and Bid Evaluation
- IT Systems
- Process Control
- Software Applications

6. a. How important is continuing education that could result in a specific engineering degree? Rank 5 - 1  
 RANKING

b. Please rate the value of having continuing education classes available as follows (5 = high, 1 = low):

- After hours (Weekdays)
- Combination
- Compressed Schedule
- Home Study
- Saturday's Only
- Year Round
- Doesn't Matter

7. Please indicate the level of education of your current technical workforce by showing the number of employees in each category:

How many of your employees...

- Are certified in a technical category?
- Have received an AA degree?
- Hold a BS degree?
- Hold an MS or PhD degree?
- Would be interested in pursuing an advanced degree if distance learning and/or after hours classes were available?
- Have no interest in this subject?

8. Would your firm participate in a program for cooperative education, internships or real-time experience if it was offered?

- Yes                                       Depends on other factors                                       No

List below:

Additional comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Use space below if needed

