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Assessing Engineering Entrepreneurship

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Abstract

Cross-disciplinary technology entrepreneurship programs are rapidly emerging in colleges and universities across the United States, as well as Europe and Asia. But what effect do these programs have on their students? How can these effects be measured? These questions are beginning to be answered in the new Engineering Entrepreneurship Minor at The Pennsylvania State University. We have brought together faculty from the colleges of engineering, business, and IST (Information Sciences and Technology) to develop a problem-based curriculum designed to encourage creativity, customer-oriented design, and to foster understanding of the entrepreneurial business world. This paper will present the outline and initial findings of our assessment plan. Lessons learned in the first 18 months of course offering will be shared, and recent improvements (inclusion of online portfolios and improved curriculum co-ordination between courses) are discussed.

Background

Two years ago, Penn State applied for and received a grant from General Electric to develop an entrepreneurship minor within the College of Engineering. The original goals for assessment were as follows:

1. Are students more motivated and more likely to perform at higher levels than students who are not exposed to problem-based learning?
2. Are students more successful in tackling ambiguous problems and formulating their own approaches?
3. Are the students more likely to see the connections to aspects of problems outside those related to their individual discipline, especially business/finance aspects?
4. Do students exhibit better communication skills and facility in working in teams?
5. Are students acquiring and improving skills that will allow them to become successful entrepreneurs?

It became apparent through literature review and our own analysis that entrepreneurship encompasses two potential areas for evaluation: Tendencies or attributes possessed by the individual entrepreneur and knowledge or skills considered important to entrepreneurial success.

In order to begin to answer the assessment questions, we developed a list of attributes and knowledge that would be measurable and support the original goals of the program. The student outcomes, both cognitive and affective, are listed in Table 1.

Attribute/Tendency	
Entrepreneurship Self-Efficacy	The learner's confidence in his or her ability to perform as an entrepreneur
General Enterprising Tendency (GET)	Addresses Need for Achievement, Risk-Taking, Need for Autonomy, Drive and Determination
Leadership	The learner's orientation towards assuming command
Customer Orientation	The learner's willingness to allow his or her efforts to be customer-driven
Knowledge / Skills / Performances	
Course Content	Mastery of course learning objectives as measured by pre- and post-tests
Entrepreneurship Attainment	Development of ideas and business plans for class and Product showcase
Communication	Ability to relate through spoken and written word and images
Teamwork	Ability to function in various roles as a group member
Innovation	Ability to apply program concepts in a new and creative way

Table 1. Student Outcomes Selected for Measurement

Evaluation of students' attributes and knowledge can be linked to several of the above assessment questions. Instruments measuring the attributes and tendencies of the entrepreneur may provide information regarding whether students are acquiring and improving skills necessary for entrepreneurship, including communication skills and team-working capabilities (Questions 4 and 5). Measures of the knowledge and skills gained by the students may provide information on students' ability to solve problems and formulate unique approaches (Question 2). Additionally, these measures might suggest whether students within the minor exhibit greater knowledge and motivation for topics related to entrepreneurship (Question 1). Outcomes related to the course content, including the development of business plans, can provide information whether students are making interdisciplinary connections among different fields (Question 3).

The minor curriculum took the form of four 3-credit "core" courses: ENGR 310 *Entrepreneurial Leadership*, ENGR 407 *Technical Entrepreneurship*, ENGR 411,

Entrepreneurship Basics (or QMM 492 *Introduction to Engineering Design Principles* for the business majors), and ENGR 497A *Entrepreneurship and New Product Development*[1]. Faculty from Engineering, Business, and Information Science and Technology (IST) were involved in the design and delivery of these classes.

Design of the Assessment

The underlying philosophy in our design was a minimum impact on the faculty and students. Where possible, the assessment was embedded in the curriculum[2]. When this was not feasible, we made use of the World Wide Web and crafted online versions of needed instruments, allowing students to complete them on their own time and at their convenience.

Three existing instruments were incorporated into our evaluation plan: An Entrepreneurship Self-Efficacy measure[3], a General Enterprising Tendency (GET) test[4], and a leadership scale[5]. These three instruments were converted to online form after obtaining permission for their use from their creators.[*] The final form consisted of 104 total items and an estimated completion time of 20 minutes. Added to this online form was a series of demographic questions related to the reason the student was taking an entrepreneurship course and previous experience as or with an entrepreneur. We planned to administer this instrument to consenting students once upon taking their first entrepreneurship core course and again just prior to their graduation. This combined measure was intended to cover all of the traits and tendencies identified above in Table 1.

The assessment of knowledge/skills/performances was based primarily on student performance in a pre and post-course content test and in a final "product showcase" event. Performance as a team member, in class presentations, and the development of ideas and business plans were assessed by each faculty member and have not been formalized across courses. The content pre- and post-tests were developed by the faculty in each course. While not considered as part of the course grade, the pre-test gives the faculty a good idea of the entry knowledge possessed by each class[2]. The comparison of the pre and post-tests (for the most part identical) provides a good indication of the knowledge obtained over the course of the semester.

The "Product Showcase" is an opportunity for teams from the entrepreneurship minor to compete for prizes. Each group is required to create a five-minute presentation (an "elevator pitch") as well as brochures and prototypes of their product. Independent judges with entrepreneurial experience rate each team's performance and awards are given.

[*] Unfortunately, due to copyright concerns, we could not include a copy of the instruments we used. Please see the cited sources for the original scales.

Student Demographics

As expected, we have gathered a large amount of data using this "wide net" approach. The goal was to have more rather than less data than we might need to determine program effects, much like over-sampling. Our e-ship student demographics are displayed in Table 2.

Entrepreneurship Minor Courses		**College of Engineering**
Total Number of Students	300	9235
Students Completing the Instrument	165 (55%)	xx
Number of Males	225	7761
Number of Females	73	1474
Age	18-35 (μ=21.69)	n/a
Semester	3-10 (μ=7.2)	n/a
Math SAT	624.54	613
Verbal SAT	565.85	551

Table 2. Preliminary Demographics

The response sample (55% of our students) was tested against the non-responding group to verify that it would be appropriate to make inferences across the entire population. Comparisons were made regarding student ethnicity, semester standing, current GPA, and both Math and Verbal SAT scores. No statistically significant differences were identified ($p>.13$ in all cases), indicating that the respondent group did not differ in these areas from the non-respondent group.

A comparison of participation rates by sex reveals that females in the college population are more likely to take entrepreneurship courses than their male counterparts ($\chi^2=16.186$, df=1, $p<.0001$). The course instructors for entrepreneurship have supported this finding anecdotally as well. Interviews and focus groups are scheduled for this year, and we will try to determine the reasons behind this phenomenon.

Our entrepreneurship students also were more likely than the general college population to have higher Math and Verbal SAT scores (math $t=1.998$, df=167, $p=.047$; verbal $t=2.307$, df=167, $p=.022$), although the actual size of this difference was slight (11 points for Math, 14 points for Verbal; See Table 2.)

The students tended to be in the 7th semester of their work (senior year). The high frequency of participating seniors was unexpected by most of the design team, and poses some problems in the assessment of the minor, since these students are obviously not intending to complete the minor requirements. Only 23.3% of our online

respondents indicated that they intended to complete the minor in engineering entrepreneurship. This low percentage is most likely due to the students' semester standing, as most of them probably recognized that they would not be able to complete the minor prior to graduation. This, too, will be addressed through interviews and focus groups later this year.

Student Outcome Data

The student data regarding entrepreneurial attributes that we have collected to date is primarily of a pre-test nature, and we are awaiting sufficient numbers to complete the post-test before we can make longitudinal inferences regarding the effect of our courses on students. A control group of non-entrepreneurship students will be asked to provide cross-sectional data for each of the final semesters for comparison, but this collection has not yet occurred. The data that we have was, however, sufficient for reliability tests on our instrumentation. Both the self-efficacy and leadership scales delivered high reliability (α=.9152 and α=.8163, respectively). The GET test, however, was less satisfying, yielding an overall scale reliability of α=.4205 and similar poor reliability at the subscale level. We are reviewing this instrument to see if and how it could be improved. If we are not able to improve its reliability, it will have to be discontinued.

Student performance on the pre and post-course content tests has been satisfactory. There appears to be a significant qualitative difference between these tests of content knowledge, indicating that solid learning of terms and concepts is taking place.

The "Product Showcase" student activity shows a great deal of promise as a data collection point. We have judges' scores for all of the showcase participants since the beginning of our program. Unfortunately, the score sheets tend to be sparse, particularly lacking in qualitative information that would be most useful both for our assessment needs and student feedback. This deficiency is also under review this year.

Performance as a team member and in class presentations has been left to the individual faculty members and is a part of each student's overall grade. This is, of course, less than ideal from a program evaluation standpoint, but teamwork within each course tended to be quite idiosyncratic and therefore resistant to a common program-wide measure.

Future Actions

While the online format has been effective in the collection of basic demographics and the testing of leadership attributes and entrepreneurial self-efficacy, the low reliabilities of the GET test will most likely result in our dropping it from our assessment plan. This is a significant disappointment, since the GET was intended to test several constructs

related to entrepreneurial tendencies. Fortunately, both the self-efficacy measure and the leadership scale are reliable measures, with the self-efficacy measure being the most sensitive to course effects and therefore most likely to be useful.

Beginning in the fall of 2002, we started collecting samples of student work using ANGEL, Penn State's online course management system. Each course now maintains a portfolio containing student-selected work from the beginning and end of the semester, along with their rationale in choosing each piece of work.

The data will be supplemented by student focus groups and interview sessions being planned for the spring 2003 semester for both current and graduated students. Interviews and focus groups with current students may not only provide information about the perceived benefits of the minor, but also provide suggestions for how to improve the program. Additionally, we expect that many of the effects of the minor may not be evident immediately, but rather will be revealed perhaps several years after students graduate. Therefore, we plan to interview students who have graduated at several points in the future. Student perception regarding the benefits of the entrepreneurship minor and its component courses may change with experience within the working world. These types of qualitative data collection should bring a wealth of information regarding program effects.

We will work on improving our data collection through the "Product Showcase", a venue where students are asked to display what they have learned through the delivery of a marketing pitch and the preparation of materials regarding a product they have developed. It seems likely that these types of presentations represent a certain level of entrepreneurial attainment, as well as an ability to work in teams. The use of outside raters is a powerful approach, but their feedback needs to be captured through an improved rating instrument and process. Additionally, for this year's evaluation, we plan to perform interviews with several student teams immediately following the Product Showcase to discuss perceived benefits and shortcomings.

We are considering the incorporation of a measure of student intellectual development, such as the Learning Environment Preferences (LEP scale) and the Self-Directed Learning Readiness Scale (SDLRS) as a measure of changes in student ability to take charge of their own learning. While the addition of these scales may be desirable vis-à-vis our original assessment objectives, we remain sensitive to the workload that we are placing upon both students and instructors. Our preference remains the use of instruments embedded in the instruction.

An additional focus for future assessment may include the evaluation of the individual courses. Although several observations have been performed on classes in the past, we have not yet formalized how this can be included into the evaluation of the overall minor. Because the courses offered in the minor are very unique, qualitative information obtained through observational methods may prove useful to other

institutions implementing similar programs.

Summary

Engineering Entrepreneurship is a complex object of measurement. Our approach has been to cast a wide data collection net, using both quantitative and qualitative measures and multiple modes (online, paper, and face-to-face). This method has generated a large amount of data that we are only beginning to interpret. Our findings to date are primarily demographic in nature, as we are awaiting post-test data on most measures. The courses that are part of the minor appear to appeal to under-represented groups within the College of Engineering (primarily women – Other data is currently insufficient). The reason for this preference may be inferred from the literature, but we intend to follow up with interviews and focus groups in order to determine the specifics in our situation. The slightly higher SAT scores of our e-ship students are a warning that self-selection may be taking place. It remains important that we target our assessment in the areas addressed by our courses rather than more general "GPA-type" measures.

References

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