

AC 2007-3045: INTRINSIC AND EXTRINSIC MOTIVATORS TO STUDY INDUSTRIAL ENGINEERING: A FOCUS GROUP APPROACH

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Intrinsic and Extrinsic Motivators to Study Industrial Engineering: A Focus Group Approach

Abstract

The literature suggests that students with intrinsic motivators to enroll in engineering programs are more likely to succeed than those that present extrinsic motivators alone. Hence, salary ambitions, perception of prestige, and family pressures to be an "engineer" are far less powerful to push a student to finish their coursework in engineering than motivators such as liking math and science, being good with numbers, loving design or having a powerful role model who is an Engineer or a close professor mentoring.

Moreover, differences in cognitive preferences are likely to play a role in the retention of these generation Y students. Those who desert engineering are likely to be stronger in verbal abilities than their staying counterparts. But their lack of ability to concentrate for long hours without multi-sensory stimuli is perhaps the most challenging characteristic of this generation.

We discuss the results of a comprehensive focus group study being undertaken at the University of Puerto Rico at Mayagüez among Industrial Engineering students from the freshmen to the fifth plus year. We concluded that a lot of attrition in Industrial Engineering education comes from a misconception of the IE field in general and of the effort required in engineering in particular and therefore, we also explored the misconceptions or mistakes in their understanding of the career choice they made and suggest additional areas which are open to further study.

Keywords: Industrial Engineering, intrinsic motivators, extrinsic motivators, misconceptions, career choices

I. Introduction

Through the years many researchers have focused mainly in understanding the students, Kierkegaard¹ believed that to be a good teacher, you must learn from the student, identify with him or her and thus gain a better understanding of how he or she learns. With this knowledge one is able to channel the material in a better way so that the student understands it better. In reality we believe that the students tend to be worlds apart from each other, each having their own personal motivators, perceptions, learning capabilities and willingness to do so.

While the inclination towards engineering is a current issue of importance, so is retention. Prior studies have determined that in the United States it is difficult to attract students to engineering and once they are in, it is also difficult to retain them in the program. In Puerto Rico, the recruitment process is not a problem; many students are quickly informed of the prestige that the University of Puerto Rico, Mayagüez Campus, has in the island. Those students, who are interested in the engineering field, find themselves applying to our university. In contrast, attrition and retention of admitted students is becoming quite a problem. Being a rigorous five year program, the Industrial Engineering (IE) department at the University of Puerto Rico at Mayagüez (UPRM) has begun to experience more difficulty than other engineering departments

on campus to attract qualified applicants. Still, attraction is not a problem in the island where there is a culture of almost veneration to the UPRM's engineering programs. The main problem has become attrition and to some extent retention. As observed through the recent years of IE students at the UPRM, there has been a tendency to average 6 years to graduation with a normal range from 5 to 7 years. In the next sections we describe the engineering program at the UPRM and the IE department in particular.

The School of Engineering at the UPRM:

The University of Puerto Rico has 11 campuses. The UPRM campus is located on the westernmost part of the Island and is the only one in the public university system where Bachelor of Science degrees in engineering are offered. Engineering undergraduate enrollment places the UPRM in the 14th position among US Engineering Schools. The UPRM's college of engineering granted 622 bachelor's degrees in the 2003-2004 period, ranking number 1 in the degrees granted to Hispanics and 23rd in the USA, in 2006 the UPRM graduated 606 engineers and nearly 39% of the BS degrees in engineering were granted to women. Industrial Engineering ranks second in the percentage of female graduates, with 60% of BS degrees granted to females in 2006.

While 8 percent of all SAT test-takers in the U.S. mentioned engineering as the intended college major in 1999, Puerto Rico's figure is higher, at 12%. The Society of Hispanic Professional Engineers cautions against comparisons regarding attitudes and beliefs between Puerto Rico-based Hispanics and stateside Latinos, mainly because the first group does not face language and racial barriers. They are a majority in their land and are benefited by unique factors regarding education and tuition in the island. Strong demand from the local market and the continental U.S. for engineers, coupled with the proliferation of colleges, low tuition costs, and generous student aid, have eased the way for high school students into engineering.

Status of the UPRM's College of Engineering in the island:

The UPRM is a highly recognized university in Puerto Rico. Its image comes from being one of the best universities specialized in Engineering and Science in the Caribbean. Engineering graduates get very competitive job offers from the many pharmaceutical, bio-technology and electronics companies in the island. Graduate school is also an option as all engineering specialties have well-established graduate programs and many prestigious engineering schools in the continental US come to recruit students, offering full scholarships to the most qualified graduates. Research wise, three fourths of its faculty has Ph.D. degrees from the most prestigious American and European engineering schools. In IE, this percentage jumps to 82%.

The UPRM has a research-oriented culture that resonates in Puerto Rican society due to a history of academic success, having nine NSF's CAREER awardees in the last ten years among its engineering junior faculty and several department heads in universities in the continental US are UPRM graduates. We will describe few aspects of admissions to understand better who these engineering students are.

Description of Admission Criteria:

The admission index, called the IGS, is composed of the high school grade point average, the verbal aptitude test score and the mathematics aptitude test score from the College Board Entrance Examination. The highest possible value of the IGS is 400. The weight of the high school GPA is 50%, while the weight for each of the two aptitude tests is 25% each.

All admission index values to engineering are relatively high. For the engineering class of 2004-2005, the minimum IGS fluctuated from 313 for Surveying to 342 for Computer Engineering.² The median of the IGS are higher for students applying from private schools as opposed to public school students. These statistics translate in that only the top tier of high school graduates is granted admission in engineering every year. Students in IE generally are in the top 5 to 10% of their classes, come from different regions of the island, different family backgrounds and types of schools.

We hypothesized that attrition and retention issues are more prevalent in students who enrolled in IE either motivated by extrinsic factors or by misconceptions regarding the skills required to be successful with its coursework or whom enrolled with misconceptions of what an IE does and what the IE career entitled. In our study most of the subjects had no real solid idea of what Industrial Engineering is and it's applications in the field. It is believed that students with deep intrinsic motivators, like: intellectual curiosity, pre-requisite knowledge, skills and the desire to enroll in the Industrial Engineering program not only are more likely to succeed in the field but also tend to do better than those students who persist in the career for purely extrinsic motivators as prestige, money, luxuries, etc. Although some external factors are also present in the way students react to their college education, these are not discussed in this article. Some students expressed a difficulty to adapt to their new found independence, depressions, the need to establish self-control to maintain good study habits, home sickness, and others. Since the topic of college education has been studied thoroughly we will focus on the motivators and how these affect the lives of the students.

To explore these issues we conducted a series of focus groups with students ranging from the first to the last semester before graduation.

This paper is organized as follows; first we review the literature on success factors in engineering, and how intrinsic and extrinsic motivators influence attrition and retention. Then we briefly discuss the methodology, followed by the focus group results and finally we present our conclusions and recommendations for future research.

II. Literature Review

It was once believed that one of the best indicators to tell how a student will do in college is through their SAT scores and High School records. the truth is that the weight of these determinants on academic success is much less than once it was thought³ as more recent findings have found that the main determinants of success are beyond SAT scores. We believe

there are a wide variety of variables that affect the outcome of how a student will do in college besides SAT scores and High School records. Also in the Seymour and Hewitt's study, *Talking about Leaving*,⁴ it is shown that while many of the college drop outs do so because of academic difficulties, many others are good students who leave because of dissatisfaction with their instruction. In fact, the students leaving engineering in this study were academically no different than those that remained, suggesting that the students left for reasons or motivators related to their perceptions of the institutional culture and career aspects.

It has been found that misconceptions that students have related to the engineering field, what an engineer does at work are in part accountable for attrition⁵. As a result of these misconceptions there has been a decline in the number of students applying to the engineering fields in the United States and an increase of students who decide not to finish the career and explore alternative paths to success. Here is when we take into consideration the intrinsic and extrinsic motivators that the students have at first to pursue Industrial Engineering and how they came to their decision.

Several external factors (or extrinsic motivators) have been found in the literature as not so powerful motivators to stay in engineering. Hence, salary ambitions, perception of prestige, and family pressures to be an "engineer" alone are far less powerful to push a student to finish their coursework in engineering than motivators such as liking math and science, being good with numbers, loving design or having a powerful role model who is an Engineer or a close professor mentoring [e.g. see^{3, 4} and⁶].

Moreover, differences in cognitive preferences are likely to play a role in the retention of these generation Y students. Generation Y is a term coined to describe the group of people born immediately after Generation X (around 1982 but some think it began as early as 1976). This is the generation that was born with a number of technology products and services that were unthinkable to the baby boomers and were in its beginning for the predecessor generation X. According to Wikipedia (www.wikipedia.com), they were the first to grow up with the Internet in a developed, prolific form, including music downloads, instant messaging and cellular phones, which came to fruition at about 1997. Even before they could type and mouse-click their way through the Internet, they were the first to grow up with modern media choices: television remotes to encourage channel flipping; cable, with its wealth of channels among which to switch; and multiple TVs (and video recorders) in a household. These TV choices reduced the commonality (and centralized control) of the viewing experience. Similarly, DVD popularity and large-screen home TVs have dispersed the impact of TV/movie events, while viewer voting shows like *American Idol* have made media more interactive.

Other major social changes in recent times include immigration and developments in race relations. Characteristically, Generation Y members are generally very tolerant towards multiculturalism and internationalism. Obviously, students in the engineering classrooms at the moment are members of this generation.

Those who desert engineering have been found likely to be stronger in verbal abilities than their staying counterparts⁷. But their lack of ability to concentrate for long hours without multi-sensory stimuli is perhaps the most challenging characteristic of this generation.

Attraction factors:

Heckel ¹² found many factors influencing the enrollments of engineering freshman. Student perceptions of potential personal financial gain may play a significant role in selecting whether they enroll in engineering. Interviewing intensity and starting salaries, indicates that such perceptions may bear little resemblance to the realities that will be dealt with during the course of professional engineering career. Studies also show that there is no correlation between enrollments of freshman in engineering and national economic conditions. Students appear to enroll in engineering with expectations and perceptions of individual economic reward and they may have difficulty in becoming involved in the curriculum which largely ignores such personal interests. Something interesting is that most curriculums contain courses in industrial economics; it is unusual that economic interests of students are included ¹.

Even though many of the attraction factors that have been previously studied and researched are focused in the extrinsic factors and motivators for studying in the engineering field, this study will also incorporate deeper, intrinsic factors to the already laid out formula of “Why students choose engineering majors?”. Like with any other profession, there are always some students who are purely interested in the outcome and what they can receive from having a prestigious degree and a nice title at work, but there is also the path of the students who wish to innovate and make something better of an already good thing. Thus, we wish to accomplish this by laying down some of the most common extrinsic and intrinsic factors of why students in Puerto Rico choose the Engineering field, focusing on the Industrial Engineering BS.

III. Methodology

Focus group is a methodology that allows the participant to voice his/her opinions and concerns in an open-ended semi-structured manner providing light to nuances and aspects of the issue at hand that no other data collection method can. Focus groups have been used in the past to evaluate engineering programs and to elicit student characteristics [e.g. 7]

Based in the seminal work of Richard Krueger’s book [8], design, execution, and analysis of the study took place over one academic (fall) semester, decision-making and follow-up reporting took place over the following month in spring.

Supported on the study objectives and target audience, the research advisor and moderator students determined the types of groups needed. Homogeneity within the groups was established as a necessary feature of focus groups and it was obtained based on ten characteristics to categorize:

- Gender (male and female),
- Outside experiences (Internship and Coop),
- Type of school (Public and private),
- School language focus (English, Spanish and bilingual),
- Transfer (Reassigned from other universities),
- City area (Metro zone and rural),
- Pre-basic (Preparatory courses),

- Academic difficulties (more than six years for graduation),
- Five years group (five years for graduation) and
- Class level (freshmen and second to fifth year students).

After the arrangement of these features twelve types of homogeneous groups were formed:

- Public Spanish high school,
- Transfer,
- Private English high school
- Private high school

- Rural high school
- Pre-basic
- Academic difficulties,
- Graduate in five years,
- Coop,
- Private English freshmen,
- Public Spanish freshmen, and
- Pre-basic freshmen.

Fifty five students participated in this project. Twenty three were females and twenty two males, all of them were undergraduate students ranging from the freshmen to the fifth-plus year. Students' were asked to complete a questionnaire regarding demographic and high school related factors, such as the type of high school they attended, the language of instruction (English or Spanish or bilingual) etc, year of admittance and expected year of graduation and other questions regarding their level of math and English in preparatory courses in the first semester. Nine focus groups were conducted controlling for those factors, the selection was made by these questionnaires.

Moderators were previously selected from Industrial Engineering students enrolled in third to fifth year and who are participating in an undergraduate research opportunities program. They were instructed in focus groups techniques as described in [7 and 8] and were instrumental in the development of the script. They conducted several design meetings with their research advisor and developed the script so that students will identify and understand for the focus groups based on the literature, discussions regarding Puerto Rican student culture and other important issues. They established the themes, questions and time table activities.

One focus group session was executed for each of the twelve types of groups. Pizza was the incentive to attract students for meetings. For each group session, a moderator and a recorder were assigned. No individual names were said during the recording process. Once all groups sessions finished, tapes transcription were made and became the basis for data analysis.

Script topics were divided in seven parts:

- **Opening Question**, what impacted students the most when they enter in college.
- **High School Gap**, Academic preparation to face Engineering studies.
- **Internal and External Motivation**, factors that influence decision making process of choosing industrial Engineering as a career.
- **Academic life at UPRM**, Description made by students about themselves and their experiences at the University.

- **UPRM Gap**, Teaching strategies whether they are effective or not.
- **Industrial Engineering Knowledge**, students' perception about Industrial Engineering.
- **Future Vision**, working as an Industrial Engineering in a short time period.

Each topic was assigned to a group of students for further analysis and reporting. A different paper was created based on each topic and findings.

IV. Validation

The results obtained are believed to be reliable and valid for this articles' purpose. From a population of about 550 Industrial Engineering students attending the UPRM, we examined around 75 students that matriculated in the fall of 2006. All of the students that participated in our focus groups were from the Industrial Engineering department and were selected through a careful process so that in represents the whole of the student body.

This paper reports the perceptions and thoughts of IE students obtained through a series of focus groups at the University of Puerto Rico, Mayagüez Campus. Each student had their identity concealed to maintain the results impartiality and keep an open environment in which the students felt free to express their experiences, beliefs, opinions and concerns at the time immediately prior to making the decision of becoming Industrial Engineers. The personnel in charge of conducting the focus groups were carefully selected and instructed on how to run a proper focus group and make it comfortable for their students to express their feelings without having to worry about a faculty member knowing their identity.

The groups were selected in this order to have access of the full spectrum of students attending our Campus. As expected, the fifth year students had more solid statements on the field and were sure of them when it came to their futures as Industrial Engineers.

IV. Results

In this section we describe the main themes or topics that appeared in the focus group discussions, beginning by a misunderstanding of the IE career, and intrinsic and extrinsic motivators to study IE. The results are also illustrated with tables which help better understand how the results for each section were reached.

A. Misunderstanding of the IE Career

Students tend to misunderstand the true concept of Industrial Engineering, most of the time it is reduced to plant management, field engineer, general management, accounting and such. The Industrial Engineer uses engineering principles, math, social sciences, and people skills to develop an efficient system which in part creates a balanced environment for man and machine with an increased efficiency. Further down the Industrial Engineers path, there is also operation research, quality control, and other specialized fields in which the industrial engineer can engage in a promising career. There's also a wide market for the Industrial Engineer, not only in the

manufacturing sector, as it is presumed by most high school students who have an interest in IE. These students enter college with what Kroll ⁸ refers to as a state of "ignorant certainty," they believe that knowledge is certain, beliefs are either right or wrong, the authorities (e.g., their professors and the authors of their textbooks) have the answers, and their job is to memorize those answers and repeat them on tests. In reality these beliefs are more like guidelines in which the student is supposed to understand to a level in which he or she knows how to explore the boundaries of what they are being taught and innovate, apply their knowledge to their respective line of work as it applies and not as definitive rules.

In recent years Industrial Engineering has escalated to high decision making levels due to its dynamism and systems developments. Basically the Industrial Engineering field is not limited as it is commonly perceived by most students when they first come to our faculty. Misconceptions of the industrial engineering field. Table 1 shows the more common misconceptions in IE students.

Table 1: Misconceptions of Industrial Engineering

Misconceptions of Industrial Engineering		Representative Comments
Lack of Knowledge of the IE field	Misunderstandings preventing students to make IE the first option	<i>I wanted to enter to computer engineering but they did not accept me, then I was accepted in IE and now I do not regret one bit. After taking language C I will not go back to computers again. I had a misconception about Computer Engineering and did not know what IE is. Now after taking IE classes I sure want to be an IE, I like it.</i>
		<i>I was totally undecided regarding engineering major. There were many factors that influenced my decision, beginning with the HS counselor and my uncle who influenced my decision to enter mechanical engineering. I found no clear info regarding IE. Once there professors begin to talk about it and then i made my own analysis... i do not want to work with machines, i want to work with people... is at that point that i decided to transfer to IE, and I am so happy.</i>
	IE is Management or Administration	<i>An IE....an administrator</i>
		<i>Management. You are going to be the boss there, give orders and supervise</i>
	Restricted to the factory floor	<i>I thought an IE was a person that was in a factory always supervising employees, and that the only job available was inside a factory. I did not know one could work in services as well...</i>
	Total lack of information about IE	<i>I had no clue</i>
		<i>In reality I was lost in space</i>
		<i>In my case, I had no clue what to study. Once I went to a conference in which there were many engineers of every branch, and I got curious about it.</i>
		<i>To tell you the truth, when I got here, I had no idea what IE was. I thought it was something with the manufacturing plant, but after taking some courses in the field I really liked it.</i>
		<i>I knew it had something to do with the manufacturing line.</i>

B. Intrinsic Motivators

Students driven by intrinsic motivators to learn and enjoyment of the fundamental subjects of engineering (i.e. math, physics, design, etc.) reach a better understanding and take full advantage of their courses ¹⁰. Usually when these students reach the classroom they already have a thriving intellectual curiosity towards the material and have not only heard of it before but are intrigued by it and how they can pursue their career. Some of these students dedicate more time to assimilating the material in different ways so that they truly learn and understand how it's applied to the field, resulting in getting better grades and a level of personal satisfaction. There are a couple of characteristics for these students, such as being efficient, organized, ambitious, curious and thriving to learn. In our study we saw a variety of students that presented us with intrinsic motivators, curiously enough their ethnicity, gender, high school GPA and SAT scores had no effect in the results.

The main intrinsic motivators we could observe were:

1. Personal goals to succeed in the field
2. Good math skills background and a liking for math and analytical subjects
3. The will to have a career with people interaction and engineering principles
4. Good physics skills background

All of the students who showed these characteristics are currently pursuing their Industrial Engineering undergraduate degree (BS) in the field and 70% of them take part in engineering related extracurricular activities as active members of engineering student associations, clubs and research programs. By exploiting their intrinsic motivators, students put forth their knowledge and drive while solidifying their leadership capabilities with their fellow students.

Table 2 shows some of the representative comments in this category.

Table 2: Intrinsic Motivators

Intrinsic Motivators	<i>Representative Comments</i>
Mathematical Ability	<i>I was always good in math but that was in High School, when you get to college is way different, we have to study more.</i>
	<i>My favorite courses were always math related.</i>
	<i>I always had a 4.0 average, when I got here it was a challenge.</i>
	<i>I always loved math, that's why I wanted to study something that dealt a lot with it.</i>
Facts that helped select Industrial Engineering	<i>I was in Mechanical Engineering, took 2 years of it and finally transferred to Industrial Engineering since I wanted something that dealt better with people.</i>
	<i>When I saw how the career was done I was happy with it and decided to stay.</i>

C. Extrinsic

On the other hand, students who are purely driven by extrinsic motivators tend to memorize facts; they limit their abilities to following the procedures mechanically, most of the times without understanding how it works. This shows in examinations when students are presented with an application exercise in which they are required to apply what they have supposedly learned to an everyday activity¹⁰. Students with extrinsic motivators, who manage to finish their career, usually tend to work in something that has nothing to do with their engineering field, or end up working unsatisfactorily throughout the length of their career.

In the literature, most of the students who presented these characteristics end up as college drop outs⁷, in other engineering branches or in other degrees altogether. In our case, students with extrinsic motivators alone certainly seem to take a longer time to complete their coursework.

Some of the more common extrinsic motivators found in our student participants were the following:

1. Family pressures
2. High school pressures
3. Desires of Success
4. Desires for a luxurious life
5. Prestige
6. Money
7. Group pressures
8. Job positions
9. Aptitude tests

If we pay close attention to the extrinsic motivators shown above, we can see that 60 % of the time students at the UPRM are forced into engineering through society's pressures, as an engineering degree from the UPRM is regarded as a very desirable by Puerto Rican society. In terms of high school education, there wasn't a huge difference between the intrinsic and extrinsic students, this being the main reason to believe that the students leaving Engineering were academically no different than those that remained. They deserted the field because of personal dissatisfaction with the field. However even if minuscule there is a slight difference between the high school education of both type of students, the ones with extrinsic motivators usually had lower grades in mathematics and science courses, while keeping a higher verbal scores, this being the reason for us to believe that these students are prone to have a better future in careers focused on those skills.

Table 3 shows some of representative comments in this category.

Table 3: **Representative comments of Extrinsic Motivator**

Extrinsic Motivator	
Family Pressures	
	<i>I wanted to study business. I am here due to my parents pressure, they want to have an engineer son, but also for the economic ambitions of wanting a higher level.</i>
	<i>"My dad is a dropout from here so he always wanted this for me... well, when I mentioned that I was going to study engineering, well, he got emotional....</i>
	<i>At home my dad has always been very strict and puts a lot of pressure. I feel that if I don't study here I am failing him</i>
	<i>I felt the obligation of going beyond what most people do... this is because my mom made lots of sacrifices. I am not Puerto Rican and when my mom came here, she had to leave everything back home. I want to pay back to her for all she did for us. I want her to feel that her sacrifices bringing us here paid off.</i>
Money pressures	
	<i>If money were not a restriction, I would be a dancer.</i>
	<i>I wanted to be a teacher but teachers do not earn money</i>

V. Discussion and Conclusion

We found that extrinsic motivators in high school students as the only source of motivation, particularly when math was not their favorite subject in HS was prevalent in cases of attrition and retention problems. To the contrary, a mixed of extrinsic and intrinsic factors as reason to enroll in engineering, are good motivators to continue in engineering, but in all cases the intrinsic ones seem to be essential. In addition, we saw that as the students continue their career and take more courses in their mayor, they tend to have a better understanding and liking of it. While other students drop out when faced with these adversities, the ones with intrinsic motivators tend to shine the most and get the best of the courses. Also their level of maturity grows and their extrinsic motivators tend to dissipate if compared with their intrinsic motivators.

Regarding misconceptions found in entering students to the IE profession, we found that there is a lack of information in HS regarding the field and a lot of misconceptions surrounding the role and places where an IE could student. The IE profession does not do a good job describing the field to HS students and many good applicants can potentially go to other areas because of lack of knowledge or lack of interest to be a plant supervisor, which is the main role found as a misconception. Interestingly enough, the second role is exactly the opposite, many students enter the IE profession thinking that they will be the boss, a manager or an administrator and have difficulty facing a rigorous engineering and math curriculum. Since the students get to college misinformed in the field, they also have some extrinsic and intrinsic motivators which arise from these misconceptions and do not necessarily apply to the field. Hence, students tend to get a better feel for the IE profession transmitted by their professors and fellow students. Many of the students tend to help one another and in part this helps the intrinsic motivators to overcome the extrinsic ones. Even though this study covers the IE students in Puerto Rico, more research is needed in this area and be expanded into greater populations of students to have a better understanding of such complicated motivators which help our students to enjoy the engineering career.

This study of course, with the right resources, could be expanded to include not only Puerto Rico, but the United States, Europe and maybe Latin America students as well. With further studies, these numbers could go up and include the United States and other countries. Students all over the world, depending on their environment, culture and other aspects have very distinctive intrinsic and extrinsic motivators to study engineering and hopefully, through investigations, we will have a solid idea of how the selection process is made by the students. Like we saw in our results, the students' motivators tend to change throughout the years, this mainly because of how they get to know their field, through enrolling specialized courses in their mayor, and levels of maturity. All of these factors can and will be tabulated to get a better understanding of how the students tend to think, when it comes to selecting a mayor.

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