AC 2007-3041: PLEASE, NO POWERPOINT! TEACHING STRATEGIES THAT WORK AND THOSE THAT DO NOT IN ENGINEERING EDUCATION

Karen Benitez, University of Puerto Rico-Mayaguez

Karen Benitez is a honor 4th year Industrial Engineering student at the University of Puerto Rico at Mayaguez and is part of a group of undergrads that participates in opportunities for research at the IE department.

Juan Jimenez, University of Puerto Rico-Mayaguez

Juan Jimenez is a 3rd year IE student being funded by the Puerto Rico Alliance for Minority Participation PR_LSAMP to work at the International Service Systems Research Lab. Juan is Vice-president of the INFORMS student chapter at the UPRM and a member of the Institute of Industrial Engineers

Yesenia Cruz, University of Puerto Rico-Mayaguez

Yesenia Cruz is a graduate student working at the International Service Systems Research Lab in issues of complex systems for disaster relief. She is president of the Student chapter of INFORMS at the UPRM.

Marta Rosa, University of Puerto Rico-Mayaguez

Marta Rosa is a 4th year Industrial Engineering student at the University of Puerto Rico at Mayaguez and is part of a group of undergrads that participates in opportunities for research at the IE department. Marta is a member of IIE.

Alexandra Medina-Borja, University of Puerto Rico-Mayaguez

Dr. Alexandra Medina-Borja is an assistant professor at the University of Puerto Rico at Mayaguez and Director of the International Service Systems Engineering Lab. Alexandra holds a Masters and Ph.D. degrees in Industrial and Systems Engineering, both from Virginia Tech, and a BS in Production of Materials Engineering from the Federal University of Sao Carlos, in Sao Paulo, Brazil. Her research interests are systems thinking, systems dynamics, service operations, economic design issues, performance measurement using DEA, evaluating success factors in engineering and the cognitive processes that occur during their acquisition.

Please, No PowerPoint!

Teaching strategies that work, those that do not and the case for and against slide presentations in engineering education.

ABSTRACT

Much has been said about retention of engineering students in the 21 century. Among the many studies attempting to identify successful teaching techniques and methods for STEM disciplines, few conceptualize success as *understanding the subject, getting reasonable good grades but also as remembering key concepts in the future*. There are even fewer studies that have asked students directly questions such as what teaching strategies have impacted them the most? Which professors have been successful making the subject clear and understandable to them and why? What did they do? As well as what would they recommend instructors to avoid?

We discuss the results of a comprehensive focus group study being undertaken at the University of Puerto Rico at Mayagüez among Industrial Engineering freshmen to the fifth year students. We asked students what they remember about professors that they feel taught them the most, and also of those that did not contribute much to their "engineering education." Among the findings, a prevalence of rejection towards the use of Power Point presentations was revealed.

Other findings and conclusions for future research are also discussed surrounding student-centrism vs. teacher-centrism.

1 INTRODUCTION

Much has been said about retention of engineering students in the 21 century. The role of the instructor and the instructional method has also been discussed extensively. Old theories of what people thought to be the best learning techniques are basically still valid, even though they are subject to be modified by more recent teaching developments. Newer theories do not always suggest alternatives or replacements; these may address a different hierarchical level[1]. However an evaluation of what a good teacher or instructor is has rarely been obtained from the most appropriate source (the student) on an open ended fashion.

The truth is that throughout their academic life, students pass through many teachers and live different experiences with them. Beyond human interaction, their passage is in fact one throughout different teaching styles and instructional strategies. Hence, evaluating a professor is more than providing a personal assessment of his/her teaching skills since each student has a different point of view of what is or is not a good teacher. But all these skills and features converge to the same point: *a good instructor is one who has the best teaching strategies to transmit knowledge.*

Porter et al[2] stated that assessing the performance of a given faculty member is a complex process. Student outcomes were characterized by them as multi-faceted because multiple learning purposes are intrinsic to engineering and sciences college education. Sadly perhaps, these authors noted that such performance bears only indirectly on the ultimate goal: student outcomes. These multiple learning purposes mentioned by these authors included intellectual development, personal development, social development, and job-oriented skill acquisition. The interplay of so many elements downplays efforts to assess what really should matter, and under what conditions. Few studies have conceptualized learning success as being an interpretation from the student or learner of the appropriate level of his/her understanding of the subject and the desired outcome of getting reasonable good grades but also as the ability to remember key concepts in the future. To answer the questions of what matters to students and under what conditions we found there were not many open ended research studies. Only a handful of researchers have asked direct questions to students themselves regarding their appreciation of good teaching skills, such as *what teaching strategies have impacted them the most? What professors have been successful making the subject clear and understandable and why? What did they do? As well as what would they recommend instructors to avoid?*

We discuss the results of a comprehensive focus group study being undertaken at the University of Puerto Rico at Mayagüez, (UPRM), among Industrial Engineering (IE) freshmen to the fifth year students. We asked students what they remember about the professors that taught them the most, and about those that did not contribute much to their "engineering education". The analysis of the focus group findings shows which are the characteristics that better describe a good instructor in the opinion of the participants, and the teaching strategies they identified with and considered the best for both learning and approving math and engineering courses.

This paper is organized as follows: Section 2 shows the objectives of the study. Section 3 attempts to review some basic concepts related to teaching strategies, instructor role and engineering education. Section 4 presents the methodology, section 5 illustrates the research results, and finally Section 6 introduces conclusions and recommendation for future research.

2 OBJECTIVES

The main objective of this study was to identify which of the different teaching strategies used throughout the undergraduate industrial engineering curriculum at the UPRM's Mayagüez campus were the most effective and efficient to facilitate a better learning process to most students. We wanted to identify teaching strategies and styles that, from the students' perspective, were more effective in ensuring that students could learn, and retain knowledge while approving their courses all at the same time. We also wanted to understand the high school experience of students and its usefulness of this background in university life style. Conclusions were based on the observations made at the focus groups, after the characterization of the results.

In section 3 we present a brief review of some of the basic concepts related to cognitive styles, teaching strategies, instructor role and engineering education found in the literature. Before getting there we want to introduce the school of engineering at the UPRM and the characteristics of its students to put in perspective the profile of the focus group participants.

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[3]. This high percentage varies a lot across engineering disciplines, being Chemical Engineering the area of engineering specialization with most women graduates (nearly 65% of them) and mechanical engineering the area with fewer (approximately 18% of their graduates were female). Industrial Engineering ranks second in the percentage of female graduates, with 60% of BS degrees granted to females in 2006. In any case, graduating more female students than males is a unique case for a coed institution and a special case for a minority institution as well. Most of the female Hispanic engineers in the nation come from the UPRM as the pipe of Hispanic engineers in the US comes mainly from Puerto Rico.

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 percent. A comparable figure is not available for Hispanic Americans. 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. In fact, more than in other places, since the 1960s, there has been a growing emphasis on educational attainment to secure better earnings and job opportunities. 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. Besides, large companies and consulting firms in the US participate in the annual job fair by the hundreds, in search for qualified Hispanic engineers. Research wise, three fourths of its faculty has Ph.D. degrees from the most prestigious American and European engineering schools. The UPRM has a research-oriented culture that resonates in society due to a history of academic success, having several NSF's CAREER awardees among its engineering junior faculty and several department heads and deans of engineering in universities in the continental US are UPRM graduates.

Description of Admission Criteria [4]

The admission index, called the IGS, is composed of high school grade point average, 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 the admissions index value 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. Consistently, the female admissions IGS has been slightly higher and with a tighter distribution than that of males[5]. These statistics translate in that only the top tier of high school graduates is granted admission into engineering at the UPRM every year. Around twenty percent of the student body in the college of engineering reported family income in the highest bracket, being at least 45% categorized by income in the low brackets of society [6].

3 LITERATURE REVIEW

No matter what kind of learner a student is, academically motivating an entire classroom can be a difficult mission. This may be due, in part, to a lack of incorporating effective motivating strategies by the professor, incorporating strategies that are effective for only a portion of the group, or disparate beliefs concerning what constitutes the "common goal"[7]. We propose that the "common goal" is to learn and retain what we have learned.

To retain knowledge, a powerful technique available to the human intellect is the use of analogies and models. Learning theories could be fitted together by analogy in engineering design, which is an extremely complex and interactive process. These learning theories (by Piaget, Perry, Kolb and others), and the effects of psychological typing should show meaningful relationships among each other. It is throughout them that a structure can be established for choosing the optimal teaching method.

Kolb's four learning styles[8] are based on the ways people perceive and process information. This author categorizes people into four types of learners:

- **Divergers (Type 1 Learners),** Perceive information through concrete experience, rely on feelings, need to express feelings when learning, seek personal meaning as they learn, and want personal interaction with the teacher and others.
- **Assimilators (Type 2 Learners).** Assimilators perceive information through abstract conceptualization and process it through reflective observation.
- **Convergers (Type 3 Learners),** Convergers perceive information through abstract conceptualization and process it actively.
- **Accommodators (Type 4 Learners),** Accommodators perceive information through concrete experience and process it through active experimentation.

Framework for choosing a strategic teaching method

Before choosing a strategic teaching method, faculty need to understand the way the brain solves most design engineering problems. Within any strategic plan for engineering, various *tactics* are

available including design methods such as brainstorming, morphology, evaluations, finite element analysis (FEA), features-based modeling, rapid prototyping, etc. But according to Eder, engineering tactics can be applied as learning techniques for anyone.
Eder[9] also proposed that problems are a constituent part of a design project. The simplest problems have essentially one solution and are well-characterized by the mathematical homework problems to engineering science courses. When solving such problems, the solver can exhibit a variety of behaviors. In one case, the solver may be well-practiced in that type of problem, the solution sequence can be chosen by instinct. In a second scenario, the solver may be aware of the type of problem, but not very practiced and the solution sequence, while well known, will need to be performed in a controlled fashion. The other case is when the solver may need to find a new way of solving the problem, in which case a general strategy and suitable tactical tools can guide him or her. Especially in this last situation, various check-and review-points should be available, and iteration and advice is likely to be needed. In the groundwork stage, the brain is programmed with facts relevant to the problem. Once the facts have been incorporated, the problem is dismissed from the forefront of the mind, and storage takes place in the unconscious. In the unconscious of our mind that keeps working problems, and that is why sometimes we find its solution in the morning after a good night sleep.

In general there are considerations applicable to every strategic teaching method (pedagogically speaking)[10]:
- **Educational objectives:** why, for what?
- **Subject matter:** what?
- **Psycho-structure (of students):** who (recipient)?
- **Media (learning and teaching means):** with what?
- **Social structure (environment of education):** where?

Teaching method (teaching algorithm): how, when?

One very important recommendation in the literature is that instructors should consider follow a standard problem solving procedure. Eder[11] emphasized this saying that within each modeling level, a (formal or informal) problem-solving procedure is necessary. He recommends six work-study questions that the instructor should ask and be able to answer:
- **When?**
- **Where?**
- **Why?:** Purpose, aim, goal, objective
- **Who?:** Customer, user, operator, society, individual, group, company
- **What?**
- **How?** Interpreted as I with what means, objects, tools, systems; I with what procedures, processes, methods, strategies, tactics.

Each of the concepts learned can be evaluated by an outside observer to establish whether a new concept has been understood and absorbed into the person's mental maps. Formative evaluations can occur by quizzes, term tests, homework, etc. Summative evaluations take place in the final examinations. An educational process can also be divided into strategies, which should be based on pedagogical principles, and tactics, which include the didactic principles and the methods of teaching and learning[12].

Several other authors have proposed strategies to address problem solving with cognitive considerations. Woods, defines problem-solving in the McMaster 6-step Strategy. Wales *et al,* describe a hierarchy of thinking strategies consisting of four levels: [13]

- **Purposes:** internal and external communication,
- **Thinking Skills:** creative and critical thinking,
- **Thinking Modes:** analysis, synthesis, evaluation, and
- **Operations:** the problem-solving steps.

The immediate task should be defined (recognized) by stating and formulating the problem in its elements, relationships, structures, taxonomies, correlations; the result is a full design specification or a formulation of a problem statement, including evaluation criteria for the proposed solutions[14]:

- I prepare, self-motivate "I want to and I can".
- I read the given problem, define the situation, define the problem as stated.
- Who is (or should be) involved? (actors).
- What things are (or should be) involved? (props).
- What happened (or what should happen)? (action).
- When did (or should) it happen? (scene).
- Where did (or should) it happen? (scene).
- Why did (or should) it happen? (cause).
- How serious is it (likely to be)? (effect).
- I gather information about the nature of the problem and the properties that the solution must have: elements, relationships, structures, taxonomies, correlations, etc.
- I state the goal.

Multi-media and education outcomes

Regarding the use of multi-media technology in the classroom Rutz et al.[15] ,propose that one of the factors that influence good final grades in courses is the use of instructional technologies because they develop student performance further as compared to the traditional classroom scenario. Authors attribute this to several factors, one of this is the Student Interest. They discover that if technologies are not without problems, students were inclined to be more captive with the content presentation compared with the traditional classroom scenario. Students of this generation which have an interest in engineering are predisposed to be quite technologically confidence and generally are not intimidated by the use of technology.

This research showed that the differences in course grades are significant at the 95% confidence interval in the following pairings:

- Streaming video class (a technique whereby information is provided by a Web server in a "just in time" format to a user requesting a large file) is significantly higher than traditional class (instructor led class that met for three contact hours per week).
- Web-assisted class (instructional content formatted for efficient delivery over the World Wide Web and was structured to promote interaction with the content) is significantly higher than traditional class.

- Interactive video class (a classroom equipped with video and audio transmission/receiving equipment connected to a remote classroom similarly equipped) is significantly higher than traditional class.

There were no other significant differences when evaluating one technology-based format against another. And except for the Web-assisted course, students did not have the sense that the instructional formats were more effective than the traditional class.

Other researchers like Winn [16] discriminated from slide presentations such as power point from technology-based instruction and basically found that Power Point presentations had a number of weaknesses and presented an threat to the learning process if not appropriately utilized. It is not the program that is the problem but the poor use of the program that causes the trouble.

4 METHODOLOGY

The Focus Group exploratory qualitative methodology was chosen for this study. Based in the seminal work of Richard Krueger's book[17], 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. Krueger understands focus groups as the methodology to get to know people's stories. Stories come from people and they tell us about how those individuals experienced an event, a program or opportunities offered by an agency or organization. Single stories give us insight but a collection of stories can help us identify trends and patterns that help us evaluate programs and services.

In fact, focus groups have already been used in the past to evaluate engineering programs and to elicit student characteristics. We followed a very similar procedure to Van Aken et al[18]

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.

Forty 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 different 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 Krueger and Van AKen et al and were instrumental in the development of the script. They conducted several design meetings with their research advisor and developed the script 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.

Questionnaire 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.

Related to teaching strategies these questions were formulated to the students:
• What impacted you the most academically when you entered college?
• What is the reason you can pass some courses without actually learning?
• Which are the teaching strategies you consider are the most efficient?
• What do you advice to professors to stop doing in class?.

In order to know how students expect to be taught, questions were directly delivered to them and data was collected. Questions were basically divided in two parts: teaching strategies, and the characteristics of a good instructor.

Data were collected, organized and analyzed by groups of students working in different research topics Results related to teaching strategies are shown in the following section.

5 RESULTS

In this section a complete analysis of the data gathered by the focus groups is provided. Determining the best teaching strategies and creating the model of the perfect instructor for industrial engineering is a very complex task since no one learns in the same way. In his article, Ponton *et al*. [19] argues "Motivating behavior is a complicated process due to its individualistic nature. People have different goals, values, and outcome expectancies and have developed different ideas on how best to reach their desired future states".

Teaching Strategies that work

We asked students *"What do you remember of those instructors from whom you learned the most [while approving the class with reasonable grades]?* The following were the major themes or qualities that appeared in the discussions around qualities or characteristics of good instructors.

a. Showing the application

When determining good teaching strategies most students agreed on the importance of demonstrating the application of the theory. Teaching the concepts and definitions is not enough. Students need to see how it can be applied to the real life in order to understand the entire concept. When a lot of information is given to a student he/she cannot have a complete knowledge of the whole idea until it is put it in practice. Students want to know how they can apply the theory to the jobs, how they are going to convert the concepts and ideas to the reality of an industry. They exhort instructors to go a little bit forward of what books present and bring into the classroom the industries´ situations and problems. One student said: "*A professor should be dynamic, enthusiastic and prepare an interactive class. The professor should state that he/she is opened to answer any question anytime, and care for the students*".

b. Help us Visualize

Another teaching strategy which is bonded with the need for application is the visualization. Especially in engineering disciplines where most of the basic concepts are abstract, instructors

need to teach visually. It is easier for the student to learn and understand the concepts when he/she can feel, see, or hear than to imagine it.

The application and visualization of the theory can best be integrated with projects. This is a very common and important technique in industrial engineering since it gives the opportunity to go to the industries and put into practice what has being learned. It gives the student the opportunity to combine the concepts of the different classes and apply them to the reality of what they are going to be doing in a job. A student expressed: "*We want to see the theory applied to real engineering situations"*.

c. Provide handouts

Taking the time to develop note handouts with the main concepts really help the student to study. It permits the student to listen more in the classroom since he/she does not have to be writing all what the instructor says. The student can concentrate more on what is being taught and does not lose a part of it. It also gives the student the main idea and directs the student on what to focus when studying by him/her.

d. Make the class interactive

An important technique when teaching is to make the class interactive. If the instructor sits on the desk and starts to read what is on the notes or the slides (such as MS Power Point presentations) the student stops listening. When analyzing the data it was found that Puerto Rican industrial engineering students want instructors to use the whiteboard instead of slides. Despite all the technological advantages they still prefer problem solving on the whiteboard, especially when it is developed by the instructor in a joint effort with the students. But instructors have to be careful because writing a lot of theory on the whiteboard is also not good because students also stop listening in order to write.

e. Be Dynamic

Students' most repeated request for a good instructor is to be dynamic. Consistently across all groups, for both female and male students the more prevalent characteristic of a good instructor is dynamism. One of the students said *"...it doesn't matter if the material of the class is tedious or boring, we can learn if the instructor is dynamic explaining it*".

When asked about what do they mean by being dynamic some students described an interactive class, different types of modes during the class, or different activities, writing, talking, problem solving, and also mentioned "movement" as a characteristic of a dynamic teacher, which can be translated into him/her moving across the classroom.

f. Be passionate about teaching

In addition, the instructor must have huge desires for teaching; the students want to feel that the one in charge of the class is interested on their progress. The instructor should suggest class goals to motivate the students. This will help them to engage in the required coursework. However, these goals must have a moderate difficulty so that the student feels capable of achieving them. In fact Ponton[20] argues that "it is erroneous telling a student that they have the requisite capability to perform a given task when, in fact, they do not can lead to student frustration, self-inefficacy, and negative judgments about the professor".

g. Demonstrate enthusiasm

The instructors should be enthusiastic while teaching their classes. They should not be monotonous in order to assure that students understand what they are taught. Instructors must know that they are preparing future engineers. For that reason is not good enough for the instructor just to share the knowledge; the students must know what, how, and why these tools and skills are important for their development as engineers.

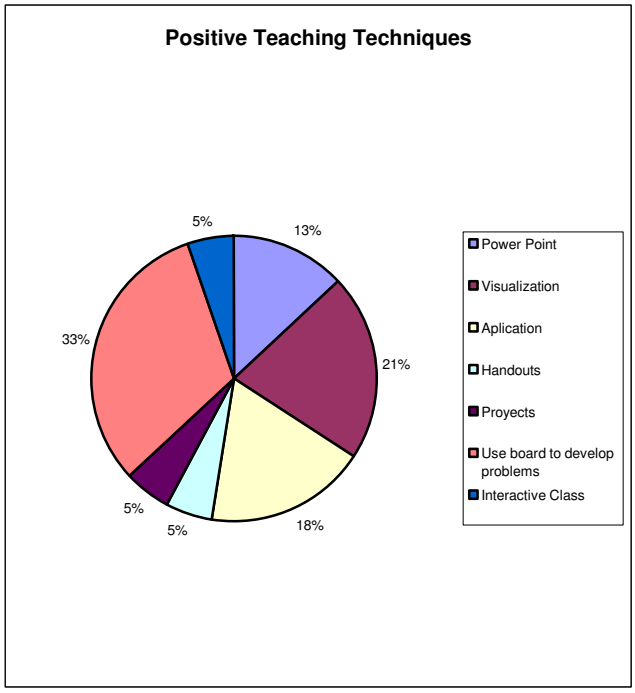
Table 1 presents the different opinions of the students in relation with the preference in a professor attitude.

Students Preferences for Professor's Attitude

Group	Professor's Attitude	Illustrative Quotes
Students from Spanish Public Schools	Enthusiastic and Dynamic	*"Some classes are very tedious, but if the professor is dynamic it motivates the student to learn."* *"Professors should be enthusiastic and want to teach."*
Students from Spanish Private School and Students from Rural Area	Dynamic and have interpersonal relationship with the students	*"Classes should be more interactive, professors should not be copying too much in the whiteboard and be dynamic."* *"Professors should develop an interpersonal relationship with students so that students feel comfortable asking them about the class concepts."*
Students with Learning Difficulties	Dynamic, enthusiastic, and develop interpersonal relationship with the students	*"The professor should be dynamic and enthusiastic in order to pay attention in class.:* *"A personal relationship with the students a necessary to be a good professor."*
Transfer Students and Students that Starts in Pre-basic Classes	Develop interpersonal relationship with the students	*"The thing that impacted me the most when I entered the university was that the professors do not care about the students."* *"In the university at Bayamón the professors worry about the students, but in the university at Mayagüez if you go to them to tell them about a problem they answer that it is not their problem."*
5-years Graduate Students	Enthusiastic, and develop interpersonal relationship with the students	*"The professors should give the classes with enthusiasm."* *"A good relation with the students helps us to ask more questions about the problems."*
Males in General	Dynamic and Enthusiastic	*"A good professor should be dynamic and enthusiastic and should like to teach."*
Females in General	Dynamic and Enthusiastic	*"Professors should be dynamic with the students; if they see that you need help they should give it."* *"Professors should not be monotonous."*

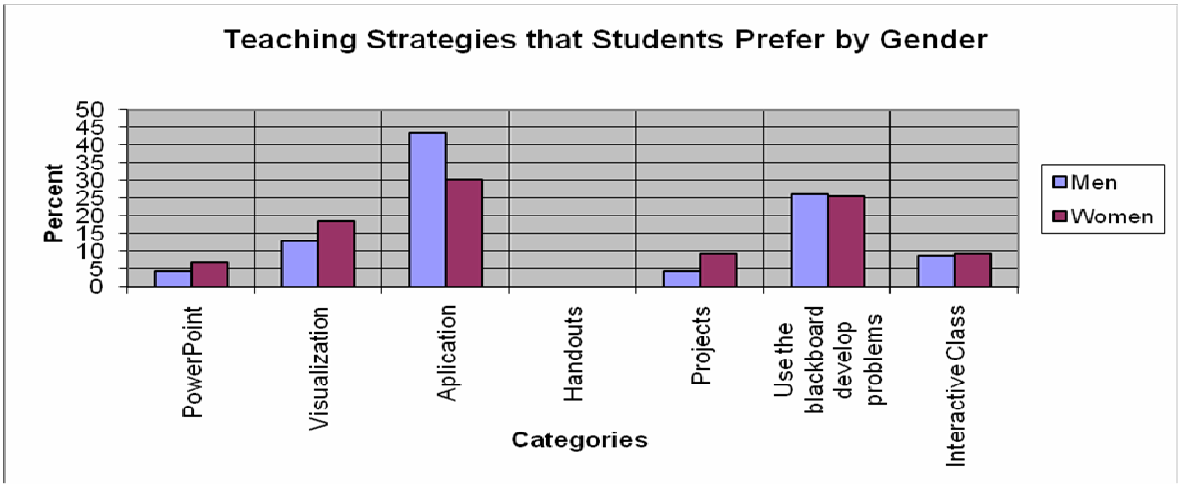
Following we present a chart demonstrating the percent of focus group participants that agreed with the good teaching techniques mentioned previously. (See Figure 1)

Figure 1. Positive Teaching Techniques



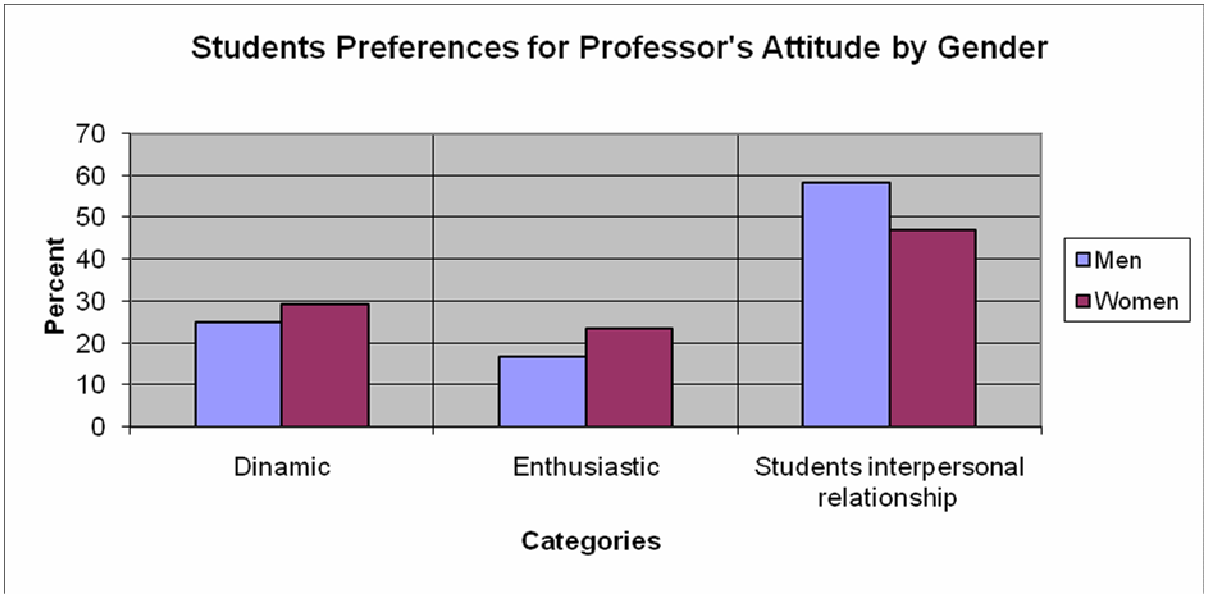
In this chart it can be seen that 33% of the students prefer the use of the white board to develop problems over Power Point or transparencies; only 13 % want Power Point to be used as reference only, to support some visualization but not as a substitution for the whiteboard; 21% likes the use of visualization techniques as a way of capturing their attention; 18% wanted the concepts to be applied to real situations, and the rest of the students like a more interactive class, handouts, and projects as complementary tools for class.

In exhibits 1 and 2, we present teaching techniques, strategies, aptitudes and qualities that students prefer classified by gender.



We can se clearly that application is one of the highest with 43% and 30% relatively. That means, that students prefer to know why they are solving a problem and how they can apply this

as an engineering tool. Graph shows that using the blackboard for develop problems continue being the one of the best way of teaching.



Students reveal what are the better attitudes, behaviors and strategies that they consider a good professor displays:

Preferred Professors Strategies (according to students perceptions)		
Group	**Desired Strategies**	**Illustrative Quotes**
Students from Spanish Public Schools	Professors should give the application of the theory, develop exercises in the whiteboard, and create an interactive class.	*"Some classes are more visual, that helps to understand the concepts better."* *"Professors should do problems on the white board and interact with the students developing discussions."*
Students from Bilingual Private Schools	Professors should prepare handouts and give projects.	*"The handouts that professors make themselves in an organized way help me studying."* *"Projects help to understand more the concepts taught in class."*
Students from Spanish Private Schools and Transfer Students	The professor should bring applications of the theory and develop problems in the whiteboard.	*"I also agree that the class should be more application and visualization rather than theory."* *"Power Point is a tremendous tool to present ideas, not to give a class. Since we are children we have been taught that the professor goes to the whiteboard, give examples to visualize what we are doing, and then is that the discussion between professor and student begins."*
Students with Learning Difficulties and Students that starts in	Students with learning difficulties and students that starts in pre-basic classes need to see the application of the	*"I like when the professors say in class for what situations we are supposed to use the theory and the techniques to apply."* *"Professors should give real examples of the industries so that we can identify how to apply the theory."*

pre-basic classes	theory to learn.	
Schools in Rural Area and 5-years Graduate Students	Students prefer to visualize the theory by developing exercises in the whiteboard.	*"Give the class very visual and do problems in the whiteboard helps me to learn better."* *"Professors should use more the whiteboard. The Power Point presentations can be use if everything is explained step by step."*
Males in General	Males prefer the application of the theory to learn better.	*"With real problems from the industries we can learn more and apply the concepts."*
Females in General	Females prefer the application of the theory to learn better.	*"I agree with him, it should be more application and not too much theory."*

Table 2. Good teachings strategies according to focus groups'participants.

Teaching strategies that do not work

In order to develop the best way of teaching it is also important to know what instructors are doing wrong. To find trends in undesirable teaching strategies, attitudes, behaviors or tools we asked students why they are not learning in the classroom, why they are failing and most importantly, why the majority of them are taking more than five years to finish the B.S. degree in industrial engineering (which at the UPRM is supposed to be completed in five years).

a. Please NO Power Point

The most talked about and controversial subject when developing the focus groups was the Power Point tool. It is said that in this century it is easier to study because of all the technological advances that students are exposed to, but the reality is that students do not completely agree. At least not in Puerto Rico. Several professors use the courseware slides that come with the textbooks and few develop their own slides. While students acknowledge that Power Point is a convenient tool, they believe it is only an efficient one if and only if the instructor knows how to use it. According to the participants, some instructors prepare a lot of slides for each session and stand in front of the class and start to read them without taking the time to explain them or giving the student the opportunity to think and understand the ideas presented. In these cases students said they do not learn during the class, they prefer to go and read them on their own. It is preferred that the instructor goes to the whiteboard and develops the problem because it permits and gives the time to analyze and understand the problem and the solving procedure. While analyzing the data it was found that students are not totally against Power Point, they are against the way instructors are using it. It is preferred that the instructor uses it as a guide to explain few key concepts and to show applications or visualizations but not for anything else.

b. Unable to communicate knowledge

A very controversial aspect that arouse in the focus groups was that instructors do not know how to explain or transmit knowledge. The reality is that to be a university professor, no credits on education or pedagogy are required. Standing in front of class and start talking and explaining concepts is not easy, no matter how much knowledge the person has.

Teaching is a gift that not everyone posses. Not being able to transmit the concepts to the students is a disadvantage because of the complexity of the subjects.

c. Do not hate your students – do not be the "strainer"

Being capable of teaching is not enough, according to students, it is also necessary to have the desire for teaching, understanding of the mission and to "love" your students. According to these focus groups participants, sometimes instructors develop the class in a way that no student is able to get an A or a B. They give exams that no matter how much the student studies he/she would fail. This is perceived as a sort of "hate" towards pupils. Sometimes the instructors even tell the students the first day of the semester that they think there are too many people in the classroom so they would give an exam to make students fail and drop out of the class. With this type of instructors some students are learning, but are not able to pass the course.

d. Imposing distance with the students

The relation professor-students must be one of trust for students. Students need to feel comfortable when they talk to their instructors. Some students feel a little afraid of asking questions because some instructors do not know how to properly answer their questions.

Professors Strategies that Students Dislike

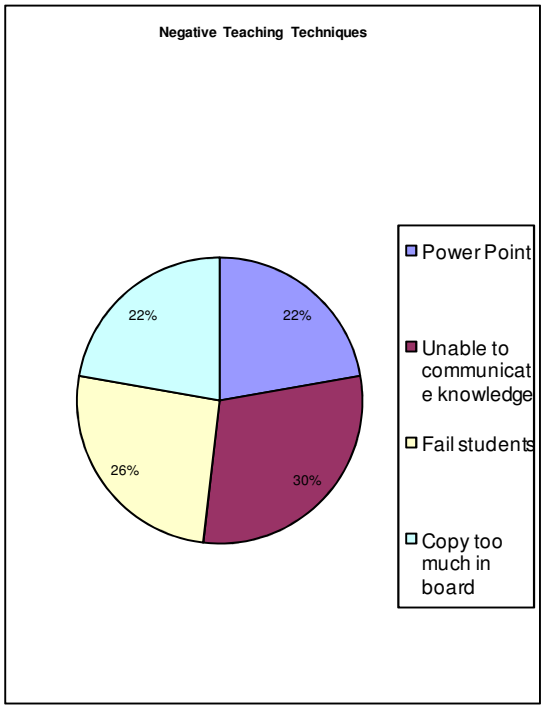
Group	**Undesirable Strategies**	**Illustrative Quotes**
Students from Spanish Public Schools, Students whom started in Pre-basic classes and Students with serious academic Difficulties	Students do not like when professors do not know how to communicate knowledge	"I think that not everyone that has a PhD can be a professor because teaching is a gift that some have and others don't. Some do not know how to transmit their ideas." "Some professors give the answers to the problems without explaining how to get to it and when students ask they don't know how to explain it."
Students from Bilingual Private Schools and 5-years Graduate Students	Students do not want that professors use the power point to give the classes.	"I think that developing a class in Power Point is not effective." "Giving the complete class in Power Point does not motivate us to go to class."
Students from Spanish Private Schools	They do not like when professor copy too much in the whiteboard.	"I don't like when professors go to class with a paper and start to copy a lot on the whiteboard because I write slowly and can't pay attention to the explanation." "Copying the whole time on the whiteboard is not effective."
Students from the Rural Area	Power Point is not effective and the professors' capability to communicate is essential.	"Power Point is a good tool but people have to know how to use it, but some classes such as Mechanics of Materials should not be given using this tool!." "Professors should be able to communicate well in order to

		teach."
Transfer Students	They think that the worst way to learn and pass the classes is when professors do not know how to teach and when they want to see students failing.	"I don't like when professors start to talk or copying on the whiteboard without explaining." "I was surprised when a professor said in a class 'You are too many in this class. I will have to clean it so that I can have fewer students by giving a very difficult first exam."
Males in General	Professors are unable to communicate knowledge.	"It helps a lot when professors explain well and write on the whiteboard."
Females in General	Professors are unable to communicate knowledge	"To find a professor that explains well in this university is a very difficult task."

Table 3. Students comments about their dislikes

In the following chart we present the percentage of students that believe these teaching techniques are not effective. (See Figure 2)

Figure 2. Negative Teaching Techniques



In this chart it can be seen that the 30% of the interviewed students think that bad instructors are unable to communicate effectively, 26% have the opinion that ineffective professors present themselves as wanting to fail students in order to reduce quantity of students in the sections, 22% believe that the whiteboard should not be used to write excessively, and the rest (22%) consider that bad instructors do not use Power Point properly.

6 . CONCLUSIONS AND RECOMMENDATION FOR FUTURE RESEARCH

In summary, we can say that for the students of industrial engineering at the University of Puerto Rico at Mayagüez, a good instructor should:

- Have full and complete knowledge of the material to be presented in class.
- Create an environment of trust for their students, eliminating favoritism during his lecture.
- Should be very clear about the fundamental ideas at the moment of the presentation.
- Use PowerPoint if and only if slides are going to be used as a reference/visualization tool.
- The whiteboard should be used to present and discuss mathematical problems.
- He/She should avoid exposing theory excessively without grounding it back to application from time to time.
- Being passionate about teaching.
- Know how to transmit their knowledge in an enthusiastic and dynamic way.
- Be dynamic, changing the rhythm of the class every certain time, changing activities and moving students, going back and forth from the whiteboard, to discussion, to in class problems, to visualization, to theory.
- Catch the students' attraction by showing the relevance of the material in his or her career.
- Make an extra effort to show the student how to get to the answer and not just the answer itself.
- Let the student know that he/she (the instructor) is interested in the student's progress.

Instructors must know that they are the eyes of undergrad students. The future of these learners is in the hands of the professionals that shared their knowledge with these students. For that reason, it is important that new engineering educators take in consideration that learners needs to know the engineering application of the equations, formulas, theorems, etc. that they are acquiring in their 5 years of college. In addition, new educators need to have communication skills and transmit their knowledge in an effective way. Otherwise students will fail and the professor will be considered as an inefficient instructor. To the contrary, having an interpersonal relationship with students will make them feel comfortable and secure themselves, in a way that they will not be afraid of clarifying their doubts. PowerPoint, as we said before, is a reference tool. Don't abuse of this magnificent program. Students let us know that they still prefer the traditional way of learning, the blackboard. Following the development of a solution to a mathematical problem being written on the board is still the best way of learning and students of Industrial Engineer at the University of Puerto Rico at Mayaguez put a lot of emphasis on that.

In summary, a more in depth analysis of the above, points us out of student-centrism, and towards systems-centered approaches, in which the student and the instructor both recognize the system of which they are elements, and work towards developing an interaction that lets students practice with problem-based aspects, but at the same time recognizes instructors' knowledge and expertise by requiring him/her to share the

application and importance of the theory, thus letting the professor lecture when deemed necessary. In system centrism, interaction is fostered, necessary and desired.

The system-centered approach has a strong focus on the complex, dynamic, inter-subjective relationships among the actors of the educational process: teacher and students. It requires an increased emphasis on teacher's contributions as learning facilitators and a concern with self and others (with students) simultaneously and in interdependent relationship. Table 1 shows the core features of the systems-centered educational approach [21]

Table 1. The core features of systems-centered educational approach (adopted from Robertson D. L.21)

	Core features	Characteristics
Systems-centered educational approach	**Educational Content**	o Diminished interest on teachers' own content mastery
	Educational Process	o The teaching strategies are focused on facilitating the students' learning process o An increased attention for the interactions on the teachers - students lived experiences
	The learners	o Strong focus on the students lived experiences the educational settings o Increased preoccupation for understanding the way in which students lived experiences interact with the teachers' lived experiences.
	Teachers' Self	o Renewed emphasis on the teachers experiences as a learner facilitator, detrimental to the teacher as a master learner o Teacher perceived as a profound human learning facilitator.
	Educational Contexts	o Students-teacher interactions perceived as a inter-subjective, complex and dynamic system o The implications of other educational systems related settings and events.

From the table above we can see several aspects of system centrism matching students' expectations of instructors' demeanor and attitude as manifested during the focus groups. As future research, the focus groups technique can be applied in other fields at the UPRM to evaluate teaching strategies for all Puerto Rican students, comparing to those of engineering students and controlling by personality and learning styles. Replicating this study in other regions in order to identify, analyze, and compare teaching strategies and students' attitudes, believes and response to different teaching strategies is also needed. This is especially important since as Porter et al pointed out[22], the weakness of feedback links from the actual teachers or learners to research reflects our sense that widespread, active communications with engineering research agendas and with pedagogical inquiries are lacking. Thus, the one study that is a natural follow up in our research agenda is to actually implement the strategies with an IE class to compare prior and current results.

The course needs to be a core IE class that traditionally has had high dropout and failing rates. We hope to report on this endeavor soon.

REFERENCES

1. Sharp J., Harb J. and Terry R., "Combining Kolb Learning Styles and Writing to Learn in Engineering Classes," *Journal of Engineering Education,* 1997.
2. Porter, Alan L, Roessner, J D., Oliver, S. Johnson, D., "A Systems Model of Innovation Processes in University STEM Education." *Journal of Engineering Education,* Jan 2006
3. (OII), I.R.O., *Graduation and Enrollment by Gender 1991-2006*. 2006, University of Puerto Rico at Mayagüez.
4. Gonzales-Barreto, D., Gonzales-Quevedo, A., *Applicant's Profile Study for Improving Undergraduate Enrollment in the Engineering School of the University of Puerto Rico at Mayagüez.* American Society of Engineering Education, 2006.
5. Ref. 4
6. Ref. 3
7. Eder W., "Comparisons—Learning Theories, Design Theory, Science," *Journal of Engineering Education,* 1992, pp.111-112, 116.
8. Ref. 1
9. Ref. 7
10. Ref. 7
11. Ref. 7
12. Ref. 7
13. Ref. 1
14. Ref. 1
15. Rutz E., Eckart R., Wade J., Maltbie C., Rafter C., Elkins. "Student Performance and Acceptance of Instructional Technology: Comparing Technology-Enhanced and Traditional Instruction for a Course in Statics," *Journal of Engineering Education*, 2003.
16. Winn, John, "Avoiding Death by PowerPoint," J. Profl. Issues in Engrg. Educ. and Pract., Volume 129, Issue 3, pp. 115-118, 2003.
17. Van Aken, E.., Watford B., Medina-Borja A., "The Use of Focus Groups for Minority Engineering Program Assessment," *Journal of Engineering Education,* 1999.
18. Ref. 17
19. Ponton Michael, Seiner J., Ukeiley L., Edminister J., "Understanding the role of self-efficacy in Engineering Education," *Journal of Engineering Education,* 2001, pp. 247, 250.
20. Ref. 19
21. Robertson D. L. 1999 Professors' Perspectives on Their Teaching: A New Construct and Developmental Model. Innovative Higher Education, Vol. 23, No. 4.
22. Ref. 2