AC 2008-1791: PSYCHOLOGICAL CONSIDERATIONS IN TEACHING ENGINEERING: AN ETHICAL MANDATE TO PRODUCE RESPONSIBLE ENGINEERS.

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Psychological Considerations in Engineering Teaching: An Ethical Mandate to Produce Responsible Engineers.

Introduction

Engineering faculty members have an ethical mandate to produce responsible engineering graduates. Faculty in engineering are required by our codes of ethics to "hold paramount the safety, health, and welfare of the public" by carefully preparing future engineers. Faculty are required to "act as faithful agents for their employers," properly serving the university, which provides education for the students. We are required "to issue truthful statements," which would include correct technical information. Our graduates must be technically competent and ethical (basic ABET outcomes) as well as well-prepared for the workplace with a readiness to work.

Engineering faculty therefore must

- communicate correct and relevant information
- communicate in a way that is understandable
- encourage and model ethical behavior, and
- prepare students for the “real world,” the actual workplace expectations they will face.

The behavioral and psychological perspective of our students should be a consideration in engineering education. The influence from the trends in the twenty first century both to students and professors can be identified. It is necessary, therefore, to consider the psychological aspects of students in order to produce responsible engineers for the twenty first century.

In this paper, in order to understand the psychological roles in engineering classes, a survey of engineering students is given and analyzed. Suggestions and discussion that can be adapted to engineering classes are presented.

Generation Y Problem

Companies tell us that they want to hire graduates who have technical expertise, good communication skills, professional ethics, and team player attitudes. They also look for graduates who are self-motivated, flexible, and possess a strong “work ethic” (desire to work.) The latter three qualities may be more “caught than taught.”

“Generation Y, also known as the millennium generation, was born between 1978 and 2000. They are the largest generation to enter the workforce since the “baby boomers,” who are now set to retire. Within a few short years Generation Y will make up the largest segment of the working population.”

Various writers have indicated that the current group of graduates is not prepared to work. According to the literature, current students are the most media-savvy and computer-literate generation yet seen. They have grown up with the internet, with cell phones, video games, and fast-paced television and video. They are very skilled at multitasking.
The downside is that they may have short attention spans, are easily bored, expect to multitask in every situation, and may have little company loyalty or perseverance. Comments in print:

1. “This age group hates to be bored and they seek entertainment in everything they do -- including college and the work they expect to do when they graduate. Many studies we reviewed indicated this generation really does have a shorter attention span. One research study actually suggested that the attention span of most adolescents is about 11 minutes -- roughly the time between commercials in a typical television show.”

2. “Free spirited and easy going, disorganized and impulsive, drifters [read “millenials”] are virtually antithetical to commanders. Their extremely short attention span means they don't pay attention to details, they fail to follow up and frequently miss deadlines. They have difficulty with structure of any kind, whether it relates to work hours, policies, procedures, dress codes or commitments.”

3. “We have noticed that twenty-somethings are frequently uncomfortable in dealing with uncertainty or conflicting data from tests. The video game culture may be influential in this area too. In video games, as in most games, there is always a correct answer which, with persistence, you can get to in the end. That’s obviously not always possible in the workplace in the necessary timeframe with real world deadlines.”

4. “It seems that they spend about the same amount of time in the office as their older peers, but more of that time is spent checking personal email and updating Facebook pages. But when they are dedicated to a project, it gets their intense full attention—albeit in short bursts. It seems to balance out.”

5. “The work ethic is dead. Younger generations in the workforce have killed it off. If you're under 30, ‘work’ has a different meaning than it did -- for the younger employee, work is something to do with your hands while chatting on your cell phone . . . unless it's something to do with your mouth while text messaging.
   ‘Are you working?’
   ‘I'm here, aren't I?’”

6. “One of the most interesting theories about why many twenty-somethings (and some thirty-somethings) behave the way they do is that growing up with video games was formative for their generation. According to a recent book on the topic of video games’ influence on this generation, The Kids Are Alright, by Beck and Wade, there is no need to be loyal to a leader, as leaders are irrelevant and often evil in video game worlds, so it’s best to ignore them. We don’t think that twenty-somethings in reality are that extreme, but they don’t work with hierarchies well and are generally fairly skeptical. They are loyal in their way—but not really to their supervisors or the companies they work with.”

Companies face two options when dealing with millenials: They can either adapt the workplace to the new workers or cause the new workers to adapt to the workplace.
“If your company has a policy of restricting websites like Facebook, shutting down instant messenger services like MSN and Yahoo, or restricting personal emails, chances are that you are lessening the likelihood of Gen Yers sticking around. Growing up with computers, cell phones and being able to immediately upon impulse connect with friends and family around the world has made this group accustomed to keeping in touch at all times.”

“Because they are used to a world in which they can be doing multiple things at once, and which their minds are always very active, they’ll come to expect the same degree of heightened stimulation in the workplace. This means they’ll have to be provided with a regular stream of new projects and varied assignments and responsibilities. Not only that, but they will have to be provided a career path that allows for multiple different jobs and careers throughout their lifetime.”

“Progressive organizations are already introducing gaming technology to support their learning initiatives. Companies like IBM and Nokia are using gaming to test workers’ knowledge of rules and regulations. Pfizer has built a simulation of its drug-development process that is used to train new recruits. PricewaterhouseCoopers has created an elaborate simulation to teach novice auditors about financial derivatives. And of course, pilots have been trained using flight simulators for years, and simulators are now used by soldiers and surgeons too.”

Similarly, faculty members face the option of changing their entire course structure to fit the student or changing the student. In terms of optimum learning we should aim to resonate with students, but in terms of poor work/study habits we should aim for change on their part.

**Needs and Trends**

The authors have heard these types of disturbing comments from some students. “I can’t learn things on my own. I need someone to explain it to me,” “Just tell me what I need to know to pass the test (or course),” “You’ll have to bear with me and give me extra time-I have trouble focusing,” “Why should I learn this? I can always look it up online.”

In order to be more effective in engineering education, it is necessary to understand our students better. Many professors express the idea that the attitude of students is different today and that their trends in study patterns are changing. There are some unique aspects about college students today.

For example, the number of students with Attention Deficit Disorder (ADD) is increasing. “Global use of medications that treat attention deficit/hyperactivity disorder (ADHD) nearly tripled from 1993 to 2003, and spending on the drugs rose nine-fold, according to a study co-funded by NIMH and published in the March/April issue of Health Affairs.”

Many educators consider that young people today are mostly oriented to a fast-changing mode. The changes over the past 25 years have been investigated in a previous paper. The present generation, called “Generation Y”, is sometimes referred to as the “gamers”. A report by Dario Nardi showed the results of changing the instructional mode from a two hour lecture to what he
calls “Rapid Context Switching” and resulted in a change from 50% attrition in his course to only 10%. The change was instituted in a freshman computer course, the student population being traditional college freshmen of ages 17 to 18, at a four year university. The concept of “Rapid Context Switching” is that students are more comfortable and adept at “jumping back and forth between different information sources and activities connecting pieces while maintaining an overall picture”14. This seems consistent with others’ analyses of “Generation Y.”

Based on these types of reports, the authors have made a number of assumptions about our students. First, young people are accustomed to (and therefore prefer) visually-oriented and fast-changing media to gain information. Second, today's students have a very short attention span, significantly limiting their ability to study or to follow detailed lectures. Third, students prefer PowerPoint presentations to traditional board lectures. Fourth, students prefer to study in groups. Fifth, the common perception towards engineering courses is that lectures are boring, subjects are difficult, and learning requires too much time. In addition, students will make choices based more upon emotional responses than logical reasons. In order to understand our students from their perspective, a survey of our engineering students was conducted to examine these traits.

Understanding Students from a Survey

A survey was conducted of 181 students in engineering courses at our university: 28 freshmen, 81 sophomores, 43 juniors, and 29 seniors. This is approximately 50% of students in our total program. The survey showed several interesting results which project significant elements. The actual survey is given in the appendix.

1. Learning styles

We expected that most of our students would be primarily visually oriented in their learning styles. However, Graphs 1 and 2 show that while the “auditory” style is the lowest, our students are not all visually oriented. Graph 2 shows that about 51% of the students are tactile. Therefore, visually oriented lectures may not be the best approach for engineering lectures.
2. Ability to concentrate

Graph 4 shows that 51% of students can concentrate for about 30 minutes without taking a break while 29% of the students can for about 60 minutes. The majority of the students within the range of 15-45 minutes were able to concentrate for 30 minutes without taking a break, and within the range of 45-75 minutes for 60 minutes.
Graphs 5 and 6 show how long students can study alone without taking a break. According to Graph 6, more than 43% of the students are able to study for more than 60 minutes without taking a break and 41% are able to study more than 30 minutes. In class, 46% of students can concentrate about 30 minutes without taking a break while 35% of these students can concentrate for about 60 minutes. The results show that most students are able to concentrate for a reasonable length of time.
3. Lecture method

In this question, students chose between “PowerPoint presented by the instructor” and “a lecture presented by the instructor writing on the board.” Graph 9 shows the result by years and Graph 10 the result by total number. Interestingly, 84% of the students prefer the writing approach, while only 15% of these students chose PowerPoint. This result is significant because PowerPoint may not be an effective tool for engineering classes.
4. Study patterns

Graphs 11 and 12 show how students can study/learn independently, and Graphs 13 and 14 display students’ preferred method of working homework assignments. Graph 12 shows that about 51% of students are able to study independently with comfort.
Graph 14 shows that about 44% of students prefer to work on the homework assignment both individually and with small group study respectively.

5. Emotional perspective toward engineering classes

Graphs 15 and 16 show students’ emotional perspective toward engineering classes. The result is quite interesting because Graph 15 shows that most students expressed that “Easy classes are more boring.” This means that our students are not motivated by unchallenging subjects, and that engineering classes must contain enough material to motivate students.
6. Goal after graduation

Graphs 17 and 18 show the students’ goal after graduation by years and by total numbers respectively. While 22% of students are undecided, 62% of students plan to join industry and 14% plan to study at graduate schools. However, the number of students who consider graduate schools is actually decreasing from freshmen to seniors. This fact needs more study.
Survey Observations

The survey reveals many interesting aspects. First, students are as much tactile as visual in learning style. Second, students prefer the board-writing method to the power-point presentation in engineering classes for their learning method. Third, students’ abilities to concentrate both in class and out of class are comparably reasonable. Fourth, it indicates that knowing our students in depth, especially with regard to their learning ability and study patterns helps to improve our teaching in engineering. This survey includes several surprisingly different results from what the authors expected. For example, students were expected to be more visually oriented in their learning styles but the results show that the ratio between the “visual” style and the “tactile” style is about even. This means that we must consider these two learning styles in teaching.

Possible Faculty Responses to the Survey Results

Results of the survey are somewhat surprising in the light of recent reports and suggest that we cannot always apply generalizations about learning habits to a specific population. (It turns out engineers are different, after all.) The findings about our students should affect the way we teach.

1. Survey results showed that our students are, by their assessment, a mixture of visual and tactile learners. In addition to spoken lectures faculty should include plenty of graphics and written-out material. For the tactile learners it is important to include laboratory exercises and hands-on projects that reinforce the material. Fortunately, our curriculum is strongly project-based and includes several hands-on projects that back up theory.
2. The estimated ability to concentrate on a problem for 30 minutes or more is encouraging in the light of comments about “generation Y” having a very limited attention span. Thirty minutes should be adequate to set up most homework problems and to solve many textbook problems. Although students may be capable of concentrating for 30 minutes, there are many more distractions back in the dorm than there used to be, including the internet, computer games, TVs, DVDs, cell phones, i-phones, i-pods, instant messengers, web cams, etc. (everything that makes a “gamer.”) Students should be encouraged to get away from all of this when it is time to study.

According to recent studies of the brain utilizing magnetic resonance imaging (MRI), the areas of the brain which govern logical, rather than emotionally-based thinking, are just being developed during adolescence at approximately college age. We suspect that this fact may be connected to the result, shown by the survey, that the students’ ability to concentrate increases as they progress from freshman to junior status. We cannot be sure, however, whether this is due to age, practice, or attrition.

3. It is interesting that the majority of our students prefer standard board lecture to PowerPoint presentation for technical material in spite of the popularity of PowerPoint in education. Certainly PowerPoint has a place in final reports, summaries of findings, and showing illustrative visuals. Pages of equations do not work well in PowerPoint. By all means, we as faculty should be engaging students, using active learning, being enthusiastic, provoking inquiry, and providing challenges.

4. Students should be encouraged by faculty both to work in teams as well as to study/learn independently, both of which are expected outcomes in ABET EAC 2000. It is encouraging that 51% were comfortable in studying independently.

5. “Easy classes are boring,” according to most of our students. This should be an encouragement to faculty to provide a continual challenge to our students (without expectations so high that they become discouraged.)

6. Most of the students surveyed indicated a plan for working in industry after graduation as opposed to attending graduate school. Faculty should begin “planting seeds” about the value of graduate education as early as the freshman year so that many of our capable students do go on for advanced study.

We are dealing primarily with students in the age group that has been termed “Generation Y,” or in the terms of Beck and Wade, the “gamer generation.” This is the generation that has grown up with cell phones, the Internet, and video games. Generation Y is the most “media-savvy” generation yet, characterized by energy and openness to change, along with a short attention span and lack of long-term connectedness. Strengths include flexibility, computer fluency, multitasking, and connectedness. Weaknesses include shortened attention span and lack of commitment to an organization or authority.
It is the professional duty of engineering faculty to prepare students to enter the workplace as professionals. What will graduates face in the “real world”?

- An expectation that they will concentrate for an hour or two in a team meeting or design review
- Face-to-face meetings rather than text-messaging
- Projects that last eight months or possibly two years
- An expectation that they can access a manual and read it on their own
- Work will seldom be as fast-paced and action-packed as a video game.

Instead of gearing lectures to diminishing attention spans, we would help students most by helping them learn to pay attention longer, to build up mental endurance. Among the techniques suggested are the following:

1. Draw the infinity symbol over and over, decreasing in size each time. This aids focus.
2. Avoid multitasking. Concentrate on one particular task.
3. Force yourself to read five more pages, complete five more problems, or work for five more minutes
4. Write down distracting thoughts
5. Reward yourself when you finish.

In terms of focus, some students have legitimate medical Attention Deficit Disorder. The policy at our university is to provide the accommodations requested by a staff counselor for any student medically diagnosed with ADD. Our ultimate goal should be to help students with ADD learn to focus for longer periods. One technique that has been proven valuable here is that of motor interaction, actually moving the arms or legs in a pattern while reading or studying.

**Ethical Responsibility**

Do we have an ethical responsibility to teach our students to give a full day’s work to their employer in order to obtain a full day’s pay from him? We would contend that to do less constitutes theft. There is good reason to perpetuate the “protestant work ethic”.

Should we teach our students: to work efficiently; avoid wasting time; concentrate on their work; do good work? Some of the following may be observed in college classrooms: sleeping in class; playing video games or checking e-mail in class (mixing work with social or personal activities); coming late to class; not keeping appointments. When students practice bad habits in the classroom, they may transfer them later to a work environment.

Students may have a difficult time making the transition from school to the workplace, because of the change of focus: As students, they pay tuition for faculty to show them how to work, but will soon be getting paid to work on their new job. Employees will probably be required to give an account of the time they spend on various work projects; they need to be taught to do this in school. (One of the authors requires that his students report the time spent on each homework problem).
Conclusions

A survey of learning preferences and psychological aspects given to our students produced a few unexpected results. Students were more tactilely-oriented than expected and many were able to concentrate longer than expected. It is imperative that faculty be aware of the traits of their students, or in the words of Richard Felder, “Meet Your Students” (our emphasis on “your.”)\(^\text{18}\)

We suggest that faculty respond in two ways to the findings of such surveys and information in the literature: (1) Where possible, provide the best environment for learning, using whatever method “gets the material across” best for an individual class. Avoid PowerPoint for derivations. Make lectures challenging and interactive. (2) Where necessary, help the students to cope with what they’ll experience on the job – the need for increased attention span, clear focus, good decision making, and long-range perseverance for difficult tasks and projects.

To teach well is to change students for the better. Therefore, the essence of teaching is to produce a change in students’ behavior, not to acclimate to their behavior. For example, ethics links closely to honesty – honesty in reporting, honesty in acknowledging sources, honesty in not copying software, and honesty in providing “a full day’s work for a full day’s pay.” Our ethical mandate is not to produce a “know-it-all”, but to teach students to:

- learn technical material well
- give their best effort (not to be entertained) and
- act honestly (including being accountable for their time).

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Appendix:

STUDENT SURVEY – LEARNING IN ENGINEERING

Participation in this survey is voluntary. The results of the survey will be accumulated and shared with
the members of ASEE(American Society of Engineering Educators) only. No individual results will be
reported on or connected to any faculty, staff or student respondent. You must be 18 or older to
participate this survey. Do not sign your name.

* Year (circle one):  Freshman  Sophomore  Junior  Senior

1. What would you say is your learning style?
   a. Auditory (I learn best by listening)
   b. Visual (I learn best by seeing pictures)
   c. Tactile (I learn best by making or doing something)

2. I am typically able to focus on a problem without requiring a break for about _____ minutes.

3. I find myself easily distracted from the task at hand.
   Very seldom  Sometimes  Most of the time
   1  2  3  4  5

4. When studying alone, how long do you usually study before “taking a break”
   (for a stretch, a walk, a drink, a daydream, or whatever)?
   a. one minute  b. 5 minutes  c. 15 minutes  d. 30 minutes  e. an hour or more

5. I am able to study / learn independently.
   With great difficulty  Occasionally  Very easily
   1  2  3  4  5

6. How do you prefer to work on the homework assignments?
   a. Individually  b. Small group study  c. Study alone, but always need tutoring

7. By which method do you think that you would learn technical material better?
   a. If it was given as a Power Point presentation by the instructor.
   b. If it was a lecture presented by the instructor writing on the board.

8. I am typically able to focus on material in class without requiring a break for
   about _____ minutes.

9. I feel that:
   (1) All engineering classes are boring.
   (2) Hard classes are more boring.
   (3) Easy classes are more boring.
   (4) No engineering classes are boring.

10. I feel more anxious than other students when taking a test.
    Very seldom  Sometimes  Most of the time
    1  2  3  4  5

11. I enjoy reading and read for pleasure.
    Yes ___  No____

12. How confident are you with your mathematical ability?
    a. Very confident.  b. Reasonably confident  c. So-so  d. Not very confident

13. What is your primary goal after graduation?
    a. Work in industry  b. Graduate school  c. Undecided

Thank you for your participation.