Student Observations over the Last 25 Years

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Abstract

Most engineering faculty who have taught for over ten years have raised a question at some point: “Is it me, or have students changed since I began teaching?” Using input from university statistics, faculty, staff, and student surveys, published literature, and course grade records over twenty-five years, the authors have identified twelve trends and observations regarding current students that impact student success and preparation for engineering careers. While many of these trends are positive and should be encouraged, a few are disturbing and should be addressed. Among the positive areas are: an increased awareness of the nature of engineering, ability to work in groups, acceptance of other students, familiarity with computers, and an increase in women engineering students. At the same time we find, in many students, a shorter attention span, less previous hands-on experience, and a tendency to expect high grades without much effort (being familiar with the grade inflation tendencies of high school.) The number of distractions (stereo, MP-3 player, cable TV, internet gaming and surfing in the dorm room) have increased, and the opportunities for high-tech cheating have multiplied. Societal trends, generational trends, higher education trends, and high school preparation all enter as shaping factors for our incoming students. As instructors and advisors we want to help make this generation of students the best that they can be.

Introduction

While researching this topic, an overwhelming number of changes were found in the past 25 years; only the most relevant set is treated in this paper, together with what the authors believe to be the three common denominators which cause these changes. One of these three has been examined in the works of F.A. Schaeffer\(^1,2\) and summarized in previous papers\(^3,4\). The second has been treated by Neil Postman\(^5\). The third is obviously technical advancement, itself.

History

L.U. is a private, non-denominational Christian university. When RWG began to teach there, in 1975, it was a college and had an enrollment of 448 engineering and engineering technology students out of a total student body of 746. The conventional student enrollment is now 1255, with 384 engineering and engineering technology students.
The second author, (PRL), joined the faculty in 1979 and has taught several EE courses. The primary author, (RWG), has observed the changes in the student body at L.U. over the past 29 years, where he has taught Circuits I almost every year since 1975\(^6\). He has also interviewed some of the present faculty and staff who have been here for a long period of time in order to find their “take” on the trends in the student body. Specifically, faculty and staff in the areas of Engineering, Mathematics, English, and the Director of Student Success have been interviewed, and their comments are summarized.

The student population entering L.U. has consisted of a large proportion of home schooled and privately schooled individuals as well as those from public schools, and a few transfer students. The SAT scores have remained relatively constant, at 1000 to 1150 for engineering technology students and 1100 to 1330 for engineering students. A very small percentage are turned away, but the school has endeavored to keep the standards uniform, especially in the Engineering Department, so that, even with a lower overall performance in Math and English skills at the input (incoming students) of our system, we have maintained high quality at the output (graduates); this implies an ever increasing “value added” to our students by the system (L.U.).

During this time period, we have observed a rising number of incoming students who need remedial courses in Mathematics and English. A recent query of the Enrollment Services Department revealed the following statistics: all apply to “true freshmen”, the descriptive phrase for students for whom this was their first time to enroll in any college:

Of 43 freshmen who were Home Schooled, 6.5% required remediation.
Of 101 freshmen who had attended Private High School, 31.7% required remediation.
Of 185 freshmen who had attended public High School, 45.9% required remediation.

**General observations**

Interviews with several members of the faculty and staff who have been with L.U. for extended periods of time yielded the following observations:

- Students are more visual now. They want to see, not hear, information.
- Students like interactive groups, expect a variety of teaching methods, and want learning to be fun. If they participate, they learn better, but they don’t like rote learning. The students’ computer abilities have been increasing; so much so, in fact, that the introductory computer course was dropped six to eight years ago, and they learn spreadsheets as an addendum in their English course. The calculator and laptops give the students a mental advantage, so that they are able to do more intricate problems easily; they can do more thinking with less attention to detail. They are more easily distracted, have shorter attention spans, and are not as good at critical thinking. Some have unrealistic expectations, and don’t know what real life is like. Their concept of real life is built on images, taken from TV or the internet. Many do only a limited amount of reading outside of magazines. They are limited in critical thinking skills. They are more willing to discuss their struggles.
More assorted general observations

A number of factors contribute to the trends we see in today’s students- generational trends (characteristics of Generation Y, Millenials), societal trends, high school preparation, and trends in higher education. Many of these trends are encouraging.

Positive trends

The authors have found the following positive trends in the entering students.
1. Students have an increased awareness of Engineering and its importance in society.
2. Students show an increased familiarity with the computer and the Internet.
3. Students are more uninhibited than in previous generations.
4. Students are now more used to working in groups.
5. There is an easy acceptance of other students from varying backgrounds and openness to new and varied ideas.
6. We see an increased number of female Engineering students.

Negative trends

The following negative trends have been observed.
7. Students have a shorter attention span with an increased incidence of diagnosed ADD.
8. They have less previous “hands-on” experience.
9. There is a decrease in Mathematics ability and familiarity with numbers, so that they have a decreased ability to estimate answers and to do mental arithmetic, and avoid memorization. There is also an increased reliance on calculators as a “magic box” which gives answers.
10. Students have an expectation of high grades without corresponding effort
11. The tendency to cheat is higher.
12. Distractions are more abundant. Internet addiction is a relatively new factor.

These items are all interrelated; some are caused by others, so that some will be grouped together in an effort to find common denominators.

Explanations of positive items

1. Technical familiarity

Students are very computer-literate, having grown up using PC’s. They rapidly pick up new software tools for calculations. They are comfortable with technology. Most own several electronic gadgets and rapidly learn how to use them; they have a strong ability to locate information via Google and other search engines. Because the incoming students have exhibited sufficient familiarity with the computer and the internet, our Mathematics Department dropped the introductory computer course about seven years ago.
2. Awareness of engineering

More students are aware of what a career in engineering entails and the courses necessary to reach that goal. Web pages, marketing brochures, and admissions counselors have made this information widely available. Increased publicity accounts for the increased awareness of Engineering and its importance in society, since the Internet offers free access to technical information presented in an interesting format (unlike that of most technical textbooks).

3. Communication

Students communicate. 60% said they communicate with a professor at least once a week. They communicate with each other. E-mail and cell phones have made communication much easier.

4. Teamwork

The emphasis on cooperation and working in groups, which has increased in our society, and which is being employed in K-12, has made the students more accepting to teamwork and group projects at the college level.

5. Diversity

Students are more comfortable working together with those having backgrounds different from their own; the trend toward diversity in our society, which has been emphasized by the media, has paid off in this area. They are also open to new ideas, probably because they have been exposed to such varied information on the Internet.

6. More women

The increase in the number of female students in Engineering is probably also due to the media emphasis on diversity, as well as social considerations. The addition of a Bio-Med option at LU has also served to attract more female students, who tend toward people-helping professions.

Explanations of negative trends

7. Attention span

Neil Postman’s book, “Amusing Ourselves to Death” indicates that the media has stifled our culture rather than making it more creative. The average attention span of a student is about 15 minutes, possibly due to television and video games, and the incidence of diagnosed ADD is growing. This is a far cry from the attentiveness of the general public in 1854 when crowds listened attentively to an address by Stephen A. Douglas for three hours, went home for supper, and returned for four more hours of address and rebuttal by Abraham Lincoln and Douglas.
Postman illustrates the problems now encountered in the classroom, by listing the contrasts between a television presentation and that which would be effectively used in the teaching of students in a classroom. The television presentation is private, sometimes teaching negative social behavior, provides no opportunity for debate or interaction, tends to present images rather than logical argument, and has entertainment as its ultimate goal.

A related problem is that many incoming students generally do not like to read, and the average vocabulary has dropped. Because of this trend textbook publishers have simplified the wording of some textbooks due to reports that students complained that they are difficult to read.

Programs which automatically plot mathematical functions have been found to be “crutches” to students, who have less understanding of how the basic functions, such as exponentials, cosines, and polynomials perform as their parameters are varied. The phenomenon can be illustrated by asking the question: do artists learn to draw by looking at pictures, or by trying to draw them?

8. Technical experience

Students, in general, have less previous hands-on experience when they enter as freshmen. In comparison with students of the 1970’s very few have worked on a car engine or taken apart a radio. There are, of course, exceptions, but as the first author, (RWG), asks for a show of hands of how many students have siphoned gasoline or water, each succeeding year the response is more meager. The authors spend a large amount of time interacting with students on a one-to-one basis, and have seen a general decrease of experience with physical interactions with the world. This is, however, replaced by an increase in familiarity with the computer and computer-related gamesmanship. Increasingly with time, students are living a vicarious life, which is much more exciting and much less realistic than real life. They watch videos, play video games, and even converse through the internet with people they have never met, and the connection between cyberspace and reality is becoming increasingly blurred. This familiarity with instant results, combined with unfamiliarity with real life, can make studies which require intense concentration seem dull – statistics indicate that a decreasing number of students in the U.S. are pursuing math and science studies, and those who do seem less apt to continue as before.

9. Weakness in mathematics, use of calculators

Students have capability and are intelligent, but motivation and preparation may have been lost in high school. In the 60’s, the motivation to pass was life or death – to avoid the draft, either subconsciously or consciously. This has not been factor for the late 70’s to the present, but in teaching, motivation is everything.

A disturbing number of students are not prepared for calculus when they enter college. Mathematical mistakes in later courses are typically made not in calculus but in basic algebra. There is a decrease in mathematical ability and familiarity with numbers, as
illustrated by the increase of the number of incoming students who have to take remedial math courses. Furthermore, students are unfamiliar with numbers and their manipulation (difficulty handling addition, subtraction, multiplication, and division). Mathematical mistakes in later courses are typically made, not in calculus, but in basic algebra. Many have trouble estimating answers, accepting answers that are off by several orders of magnitude if the calculator says they are so; and they are averse to doing simple problems in their heads or on scrap paper. They do not like to memorize formulas or numbers. All these seem to be the result of an increased reliance on calculators as a “magic box” which gives answers mysteriously (this not surprising, since many school systems introduce calculators by the fifth or sixth grade. Punching in numbers is a lot more fun than hand multiplication or long-division.) The first author, (RWG), has seen whole classes require far more than the ten minutes allotted for a quiz, which had been given a couple of years previously and which had been done in an average three or four minutes time in previous years, because of the advent of graphing calculators. The pre-graphing calculator students did the problem easily, by insight into the way parameters changed the equation; the more recent students did it by graphing the equation, and, by trial and error, tried to change the various parameters in order to see the outcomes on the graph.

Since students are familiar with calculators, they don’t think they have to memorize formulas or constants; however, engineering education consists not only of teaching how to do certain problems but also of memorization of basic concepts on which to build those algorithms. The limit of the opposite teaching is “I want to be an engineer, so I’ll buy some engineering books and go to work; no degree or experience is necessary”. If it is not necessary to memorize anything, why even memorize the alphabet? You can always look it up. There is a common concept prevalent lately that our job is to teach students how to learn, not to simply teach them information. This is called “learning to learn,” but it overlooks the possibility that you learn to learn by learning.

The previously mentioned familiarity with the computer has resulted in a heretofore unobserved uninhibitedness (or recklessness) in the use of the computer or calculator to solve problems and compose statements. Since a mistake can be easily changed or sentences rearranged, the modern student is able to compose documents or solve problems by trial and error; the computer has become almost a part of the student – an extension of his body and mind.

We have observed that those students who are most familiar with computer usage often tend to be intuitive learners, or, phrased differently, “parallel learners”. This is reasonable, since a person learns how to use his own appendages and his language in the same way. This trait may, however, lead to some negative results, also, as seen later.

Those familiar with computers tend to employ parallel or intuitive learning as opposed to sequential learning. The examples are as follows: plane geometry fosters sequential learning, in which case one may arrive at a non-obvious conclusion by a series of applications of basic precepts. Language learning, however, is largely intuitive – one does not hand a dictionary to a baby in order to teach him a language; he learns by trial and error. According to Postman, the written word is sequential and propositional, as
opposed to the videographic presentation of information used by television. Thus, we would expect our culture, which has moved from a book-oriented to a television-oriented one, to consequently move from a sequential to a parallel learning dominated culture. In Postman’s words:

“To engage the written word means to follow a line of thought, which requires considerable powers of classifying, inference-making, and reasoning….in a culture dominated by print, public discourse tends to be characterized by a coherent, orderly arrangement of facts and ideas. The public for whom it is intended is generally competent to manage such discourse.”

10. Expectation of high grades, motivation

Many students have an expectation of higher grades without a corresponding effort. Students are often prepared in high school to expect high grades with little homework and modest effort. “Grade inflation”, experienced in grades K-12\textsuperscript{14}, and now shown to be evident in universities\textsuperscript{15,16,17} accelerates this tendency over time. This accompanies a “consumer” mentality, which works against the idea of the university as a community of learners. There is a lower incidence of work ethic, a lower motivation to learn, and the tendency to cheat is higher\textsuperscript{18}. As a logical consequence of all these traits, students don’t study as much.

All these tendencies seem to be related. Since high grades are easily obtained with very little effort in high school, they are also expected in the university. Also, having been brought up in a television-dominated environment, the student’s world view has a large component that is purely virtual. Students tend to expect that the real world is similar to that presented on television, in which problems are solved in one hour, and all endings are happy, regardless of the input effort.

11. Ethics, cheating

Many students have developed ingenious ways to cheat using technology –wireless phone messages during an exam, searching for posted homework solutions, using websites with ready-made term papers, sharing solutions via email. Copy-paste plagiarism is a serious issue in English classes around the country. Many students have downloaded and shared movies and music files. Reserve books may be removed from the library if a student “needs them” for a project. A survey from the Management Education Center at Rutgers found that 75 percent of high school students admitted to cheating\textsuperscript{19}.

Cheating is on the rise – this is also related to the change in students’ performance, and calculator use. High-tech cheating has become a new challenge for higher education\textsuperscript{20,21,22}. If it is permissible, and even encouraged, to work in groups, to consult with others, and to depend on one’s calculator to perform calculations, the line between what one is responsible to know and what can be found out from others becomes blurred. If one knows where to find answers, isn’t that sufficient? If it is even encouraged to work
in teams, what’s wrong with teamwork on a test? The present culture is becoming increasingly relativistic, and many students welcome the concept that what is wrong in one culture can be right in another.

Although the incidence of cheating can be linked to calculator use, one must consider the possibility that the cause may be due to the gradual worldview shift in our culture. The word “worldview” can be used in two senses; one, a broad sense, means a person’s outlook on life; that is, one’s basic philosophical presuppositions about the universe and our place in it. The other, carefully defined term of “Basic Worldview Category” (BWC), describes three worldviews upon which all other worldviews depend, and are mutually exclusive by their definitions. A society’s culture evolves from one of these three BWCs, and the traditions and idiosyncrasies of that society can be traced to it. This topic is discussed in another paper. Many students are ethical relativists, unwilling to acknowledge any universal standards and holding a curious belief that “it’s only wrong if you get caught.”

To further compound the problem, advancing technology is providing more ingenious ways to cheat.

12. Distractions, addictions

The average college student has in the dorm room not only a computer connected to the internet but a radio, a television set (often with vcr and dvd player), a stereo, and an mp3 player. Sitting down to serious study can be a challenge. Whereas students in earlier years went out to the movies on the weekend or rented a video on Friday or Saturday night, many of today’s students will watch a dvd almost any evening. Online video games such as computer chess with players across the country can cause a bright student to lose focus and even fail out of school. The possibility of surfing the web all night or becoming hooked on computer games or internet pornography is a real danger that is addressed by many university student offices.

Basic sources of the changes

There are three basic sources for these changes:

a. Most important may be the slow drift of our culture in terms of worldview toward a more relativistic one. This may account for the rapid rise of cheating, as well as the tendency toward lethargy (lack of motivation to learn, study, or have a work ethic).

b. Second in importance is the change of our society from typographic to videographic, essentially, an epistemological change, so that the majority of the population are moved by feelings rather than by logic. This produces a short attention span, and makes the pursuit of mathematical topics more difficult.

c. Finally, there is the rapid advance of technology, the internet, and its availability to anyone in our society.

How to deal with the changes
Teachers are agents of change. The first two sources above are negative influences, and we should do all in our power to reverse them. The third is positive; as engineers, we are responsible for the advancement of technology, and should use it for advantage in teaching and reversing the first two. Also, as engineers, we know that such a colossal job needs to be cut into smaller pieces. The purposes of a college professor are to help students break down a huge subject and learn it in small pieces; to help explain the difficult concepts; to hold students accountable for their learning; to help students become independent learners; to help students learn follow-through and completion of a task; to help students learn skills in communication; to help students learn character; and, to reinforce ethics.

Our solution follows.

Howe and Strauss have characterized the current crop of college students as affluent, educated, diverse, and optimistic. They are also typically visual learners and feeling oriented, in contrast to most engineering faculty, who tend to be auditory learners and more theoretical on a Myers-Briggs analysis. A new paradigm has been developed to communicate with, and to appeal to, today's students, including collaborative learning, web-based learning, and smorgasbord curricula. While modern technology may be used to benefit the instructional process, there are some disadvantages to using it inappropriately or prematurely. In our enthusiasm to be on the cutting edge of technology, we must not overlook some basic, time-tested principles of instruction. Certain critical factors (maximum rate of information input, processing rate, decay rate, and compression ratio from textbook to lecture) will put an upper bound on learning rate. Consideration must also be given to the observation that some entering students are not well-prepared for engineering study, and many have found ingenious ways to cheat. Each of the new tools has a place, as long as we understand its usefulness. In the light of this, what is the place of the professor? Shall we throw away our chalk and abandon the lecture entirely? As faculty, we would like to believe that teachers are indispensable. In truth, students could get along without them, but there is an advantage to having a real, live teacher, instead of a textbook or computerized presentation. In addition to the traditional roles of a teacher, today's professor will be involved in learning diagnostics, in helping the student to become an independent learner, and in facilitating a basic change in the student's culture (from collegiate to professional.)

Perhaps the present trend to try to teach students in the way they most naturally learn (tactile, auditory, etc.) is getting out of hand. The purpose of teaching is to change the students, so that we need to also make them acquainted with new ways to learn.

Wrong responses to the trends would be to change the textbooks, making the problems easier, accommodate grade inflation, teach to a test (such as the FE exam), or entertain instead of teaching.

Better responses follow:

1. Attention span
The typical attention span of a college student is about (15) minutes, possibly due to television and video games. In response to this, educators are encouraged to keep their class segments to 15 minutes or shorter, to keep the classes lively, and to use audio-visual media wherever appropriate—all good ideas. However, many detailed derivations, problem solutions, and case studies require far more than 15 minutes. In industry, management presentations and meetings can run several hours. To best help our students, we need to also help to stretch their attention spans, a little at a time.

Students have a shorter attention span now—should we cater to it, or remedy it? Power point presentations can be flashy and exciting, but they are made in a darkened room, conducive to drowsiness. If they are given a handout of the power point presentation, also, they have no incentive to take notes—so, why not just tell them to read the book and skip class?

What benefit comes from coming to class, taking notes and studying them later, anyway? The answer is that, in a good lecture, the book’s information has been concentrated. The first author (RWG) finds that it takes about 8 hours to reduce information to a good one-hour lecture. It is presented in such a way that students can take notes, which keeps them awake and alert, and then they can study the examples given and practice the concepts by doing homework.

The fact that the information is erased away soon is an added incentive to take notes, which aids understanding. Learning must be uncomfortable to be effective. Furthermore, the board can be modified and the class can see a given problem as a whole unit on the board, so that various points can be modified or emphasized when it is complete. Thus students can see the beginning of the problem and link it visually with the result. This provides an excellent medium for interaction with students, and allows spontaneity.

2. Hands-on familiarity

Provide several lab courses and projects for students to develop skills in designing and fabricating projects; some examples are:
Build and test an amplifier
Design and present a “Rube Goldberg” project
Design and build a power supply

3. Mathematical ability

The first author, (RWG), gives five-minute “pop quizzes” which require that the students write formulas down from rote memory. A close correlation has been found between the results of these pop quizzes and those results obtained on quizzes on which they are allowed to use their calculators to do problems. In other words, if they don’t have the formulas memorized, they are unable do the problems, even if they have a calculator.
The calculator should only be used when hand calculations are so familiar that they are boring. Students are seen using the calculator as a “magic box” to give answers, when they have no idea what the box does. One solution is to give some “no-calculator” quizzes and parts of exams using only simple integers.

4. “Grade inflation”

To prevent this, assign daily homework, expect 2 to 3 hours of study/homework for each hour in class, and encourage students to account for their time spent on the topic outside class.

5. Cheating

It is important to have a clear, written and enforced policy to deal with cheating, along with motivation for ethical behavior.

6. Distractions

Warn students of the dangers, and encourage them to keep track of the actual time they spend in study without TV or the internet. Whereas students in earlier years went out to the movies on the weekend or rented a video on Friday or Saturday night, many of today’s students will watch a DVD almost any evening. Online video games such as computer chess with players across the country can cause a bright student to lose focus and even fail out.

7. Miscellaneous useful ideas

Give pop quizzes over key concepts, provide supplemental problems, supply links to relevant web sites, encourage students to study in teams, provide various opportunities for design in the curriculum, emphasize the fundamentals, give quizzes without calculators, stretch their attention span, work on estimating numerical answers, to foster “engineering judgment”, and use Power point, but don’t throw away your chalk.

The first author (RWG), had hoped to find a trend in the grade distributions of his students in Circuits I over the past 25 years, since he has been keeping accurate records for at least that long. After having plotted the grade distributions over that period, no trends were found. Pass rates for that period were constant, in spite of the amount of material covered. Certain problems were also chosen that had been given over that period of time, and the pass rates on those specific problems were compared, given a time span of, in some instances, fifteen years. Still, there were no trends. For this reason, all the observations are anecdotal. Perhaps there are trends which cannot be seen because the data samples are too small. Teaching techniques have been changed constantly to compensate for observed changes in students; in particular, the number of pop quizzes and no-calculator tests have been increased in order to make up for the lack of certain
skills in the students, and the wide variations obtained indicate that there are too many variables to determine whether or not a trend actually exists. The overall observation after this study is that the difference between the good and poor students is more pronounced lately; that their math skills at the beginning of the course are worse, overall, and it is now necessary to teach, not only circuits, but algebra, trigonometry, calculus, and basic arithmetic now, whereas this was not previously the case. The students emerge at the end of the course with the same proficiency with the material taught as in 1975, however. It simply seems harder to get them there.

Another professor in our department, Dr. Donald Knoop, gave the same final examination every year in his mechatronics course, from 1996 to 2003, never revealing the contents of the exam. The average grade decreased over that time at about 0.5% per year. The average class size was 18 over that time, increasing with time to 39 in 2003. The conclusion is that students have definitely changed over the last 25 years, but it is still possible to use the advantages and overcome the disadvantages in order to educate them.

Conclusions

The data provided at the end of the “History” section of this paper seems to indicate some problems in the public school system. A close look at this is warranted in the future.

Parker Palmer, in The Courage to Teach, gives a stern warning: Don’t blame the students for the problems with students—

“The ferocity with which some faculty members insist that today’s students are vastly inferior to those of their own generation makes one wonder whether social change alone can account for such dramatic decline. Perhaps the DNA itself has degenerated within the past quarter century!...Criticizing the client is the conventional defense in any embattled profession, and these stereotypes conveniently relieve us of any responsibility for our students’ problems—or their resolution….The way we diagnose our students’ condition will determine the kind of remedy we offer.”

Educators have a great responsibility to diagnose properly the problems that they see, and to take careful and caring steps to correct them.

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Biographies

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