# Retention of Information – Improving the Engineering Outcomes

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## ABSTRACT

The educational outcomes for civil engineering require students to meet specific performance standards at the time of graduation. Courses involving these performance standards are taken several semesters prior to graduation; therefore the challenge is to encourage the students to maintain their proficiencies until their senior year and beyond. Maintaining those memories is an issue. Research in the field of memory demonstrates that how quickly and reliably students recall depends on; activation or how long since they last used the information and strength or how well they practiced it. Standard departmental practice dictates passing a Senior Exam similar to the Fundamentals of Engineering exam, and completing a Senior Design project. Data from several years of administering pre-tests of pre-requisite material clearly indicate that student retention declines rapidly over time. A researched technique for memory improvement is Preview, Question, Read, Self-Recitation and Test or "PQRST". This technique pertains to our strategies. Our department has adopted two strategies to combat this loss of retention. The first strategy involves requiring students to pass an end-of-year exam that includes all completed subjects. Students failing the exam are required to enroll in a one credit review class. If they do not pass this class, they must transfer to a non-engineering major. End-of-year exams cover: mathematics, chemistry, ethics, computer programming, engineering economics, and eight engineering science subject areas. The second strategy involves maintaining student proficiencies in written, graphic and oral communication skills which are not included in the end-of-year exam. The department has developed standards to which the students must adhere in all classes throughout their tenure. Work not meeting the communication standards is returned for correction. The communication standards are distributed to each student in the form of a department handbook, and the standards take effect as soon as the student completes the associated course.

## Introduction

Learning retention is well studied in education research (1, 2, 3). Memory can be described as the ability or capacity at which human being store and retrieve information. On the other hand, all educators must also be aware of how students forget? A traditional theory of forgetting that pertains directly to this investigation is that the memory trace simply *decays* or *fades* away, as researched by Woodworth and is shown in Figure 1 (2). Past engineering practice dictates passing a Senior Exam similar to the Fundamentals of Engineering exam, and completing a Senior Design project. Data from several years of administering pre-tests of pre-requisite material clearly indicate that student retention declines rapidly over time. Research by Spache and Berg (1978), and others have demonstrated that a simple study method significantly

improves understanding and memory (3). The method takes its name from the first letter of the five steps that one follows - preview, question, read, self-recitation, and test or "PQRST". With this method in mind the CE department began 4 years ago to test standardized material at the end of each year.

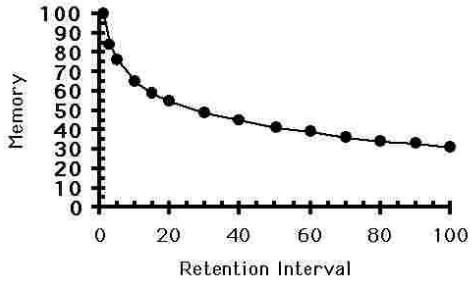


**Figure 1: Spontaneous loss of information over time. Classic shape of the forgetting curve (Woodworth).**

**Student Expectations and Assessment, Strategy I:**

The more clearly students know the expectations and the more practice they have, the greater the probability that they will acquire the desired skills (4). A useful approach to achieving any desired outcome is then to show the students the course learning objectives that address that outcome on the first day of the course. This practice began in the student's freshman year. The idea that they would continually be held accountable for all core course material was planted and this idea was fertilized and watered throughout their undergraduate tenure.

As with all problems there are several variables to be considered. The students play a part as well as the faculty. As a start for the students, the minimum passing grade for all mathematics, science and engineering science courses increased form a "D" to a "C". The start for the faculty began with selection. The majority of faculty selected to teach key courses were chosen based on their commitment to teaching and to the concept. These faculty are then held accountable because their annual evaluation is based, in part, on how well the students perform on the end of year exam. This seems a daunting task for students and faculty alike, but the initial group of students knew the expectations from their first class in the department, and faculty work on teams to develop a reusable data-base of questions.

The faculty teams every several years produce a menu of problems with 15 to 20 problems in each subject area. These are basic definition and single-step problems with multiple choice solutions. As a student progresses through the curriculum they are responsible for more test topics. For example, a freshman may only be tested on chemistry, and calculus but a junior will be responsible for chemistry, calculus, Engineering Economics, Statics, Mechanics, Differential Equations, Thermodynamics, etc. This all depends on the individual student's progression through the curriculum, i.e. all juniors may not be tested on the same material. Emphasis is placed on Calculus I, II, III, Differential Equations, Probability and Statistics, Statics, Dynamics, Strength of Materials, Electrical Circuits, Fluid Mechanics, Thermodynamics, Engineering Economics, and Chemistry. In order to assure compliance with the testing

component of the plan there is a zero credit class added during Spring semester as a place-holders for the end-of-year test (EOY) grade.

Keeping in mind the PQRST method the students are encouraged to question, read and self recitate before the test. To facilitate this process, the problem set of representative questions is available to the students in the form of a CD. Once the students have prepared there is a web-based explanation of the solution to each problem. The end of year exam consists totally of questions from the menu of problems with numbers changed so that answers cannot be memorized but the process must be learned. The problems are multiple choice and the students are given approximately 2 minutes per problem. This process also serves to familiarize the students with the FE exam format. The passing of the test each year requires the students to have reviewed the core material at the end of each year. By this process, the memory curve shown in Figure 1 can be modified as shown in Figure 2. The overall level of memory retention will lie on the horizontal line. When the students have to question, read and prepare each spring for the exam the overall memory is improved.

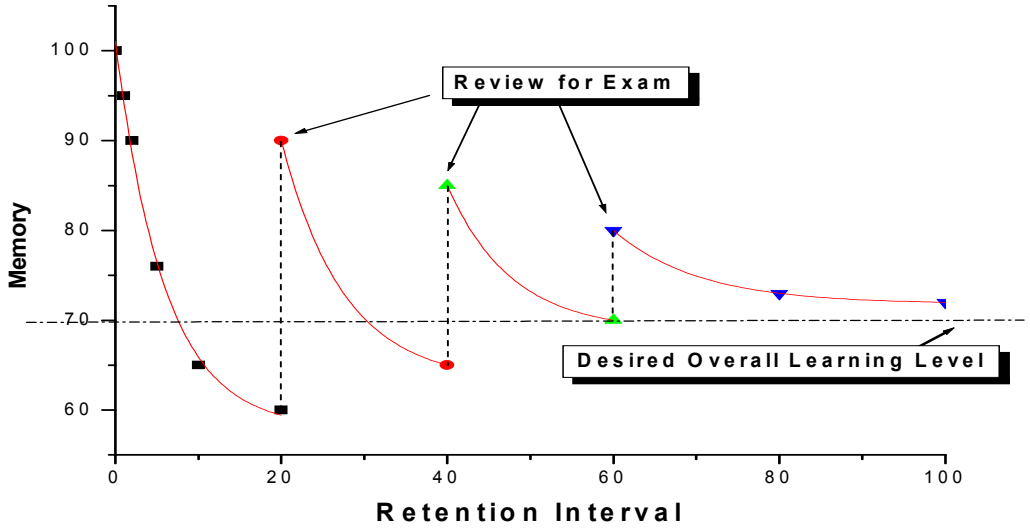


**Figure 2: Our original theoretical memory drops with added EOY reviews.**

Faculty instructors for the related courses are encouraged to use this problem set for quizzes and hour exams (20% of the exam being multiple choice). Faculty annual evaluations include a review of how well their students performed in their topic areas on the end of year exam. In the case, where a student is not successful in passing the EOY exam in May, they are given the opportunity to take the exam again in August. The idea being they must prepare again and once again add a peak to the memory curve. If the fail both times, they must enroll in a 1 credit hour review course. If they fail the course the department is confident the student is not suited for the program and they must transfer from the program. The senior students are preparing to take the FE exam, therefore during the Spring semester, upper-level dept faculty

mentor FE applicants for the 3 1/2 months prior to the FE exam. Each faculty member mentors up to five students. This mentoring program keeps the students on task and accountable as well as providing encouragement.

**Strategy II:**

The second strategy involves maintaining student proficiencies in written, graphic and oral communication skills which are not included in the end-of-year exam. The department has developed standards to which the students must adhere in all classes throughout their tenure. The challenge is the across the board use of these standards by all instructors. Work not meeting the communication standards is returned for correction. The communication standards are distributed to each student in the form of a department handbook, and the standards take effect as soon as the student completes the associated course. These courses occur throughout the student's tenure and the expectations are standardized. This helps the students in addition to providing a standard base of comparison over the years. Once again, the faculty plays a significant role in this strategy's success.

**Results**

Engineering Student attitudes have changed significantly over the past five years. In 1990 students resented having to take a senior exam and/or the FE. The culture has changed and so have their attitudes. Students seem to accept the fact that preparation for the FE is an important part of career preparation. While it may be difficult, they seem to accept it a positive way. The end-of-year exam data also provides a tool for assessing the students' retention of knowledge. The data tends to dispel the popular misconception by the students and the faculty that students do not retain basic concepts in a course beyond the final exam. Prior to the pilot project seniors typically complained that they we unable to adequately prepare for the FE because they didn't retain sufficient knowledge from courses that they completed two or three years ago. Since the end-of-year exams have been implemented, the data clearly indicate that students do retain most of the knowledge that they achieved in the course. Student ratings of the FE review course have improved significantly over the past few years because of the students' change in attitude. Typical EOY results are displayed in Table 1. One hundred and twenty nine students took the EOY exam.

Several conclusions follow.

1. Students' mathematics skills improve as they progress from the freshman year to the junior year and the skill levels are generally acceptable.
2. Chemistry skills remain constant and are acceptable.
3. Computer skills are low for freshmen and sophomores but these improve.
4. Statics skills are acceptable for sophomores but they decline for juniors. This may be caused by a lack of review by the juniors for the EOY exam.
5. Dynamics and Strength of Material skill levels are low for both sophomores and juniors.
6. Circuits, Fluids and Thermodynamics skills levels are low for juniors.
7. The pass rate for freshmen and sophomores was acceptable. The pass rate from juniors was not.

| Topic | # Problems | Freshmen pass rate | Sophomore pass rate | Junior pass rate | Average pass rate |
|---|---|---|---|---|---|
| Alge/Trig | 5 | 66% | 75% | 80% | 74% |
| Diff Calculus | 5 | 44% | 61% | 59% | 55% |
| Integral Calc | 5 | 47% | 54% | 54% | 52% |
| Chemistry | 3 | 50% | 62% | 57% | 56% |
| Computers | 2 | 36% | 37% | 52% | 42% |
| Statics | 5 | | 57% | 39% | 48% |
| Dynamics | 5 | | 44% | 34% | 39% |
| Strength of Mat | 5 | | 36% | 22% | 29% |
| Circuits | 5 | | | 34% | 34% |
| Fluids | 5 | | | 30% | 30% |
| Thermo | 5 | | | 20% | 20% |
| # Pass/Fail | 50 | 39/31 | 24/11 | 6/17 | |

**Table 1: End of Year Exam Results: May 2004**

In addition to student attitudes changing, faculty attitudes have also improved. Faculty has always complained that students were weak in the fundamentals. Once they are shown that student retention is actually rather good, their attitudes towards the students have improved. They are becoming a part of the solution. Since the pilot project was phased in, the first year that all CAAE students will be required to take the F.E. exam is 2005. None-the-less, in 2003 all Civil Engineering graduates voluntarily took the F.E. and their pass rate was 100 percent. Over the past three years the number of CAAE students who have voluntarily taken the F.E. exam has tripled and during the same time frame the passing rate has doubled. While the pilot project is an obvious success, whether this strategy is feasible on a college-wide basis is unclear.

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**Biography:**

Cindy Waters, (PhD. Mechanical Engineering NCA&T State University, MS and BS Materials Science, Virginia Tech) is an Adjunct Assistant Professor-Research Scientist in the Department of Mechanical and Chemical Eng. at NCA&T State University, Greensboro, NC, in addition to being a part of the Center for Advanced Materials and Smart Structures. She has taught in the School of Engineering for the past 12 years. In addition to nano-film research she is working with the educational component of the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS). The center is funded by the National Science Foundation (NSF).

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