Learning Skills for First Year Engineers

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Abstract

Engineering programs looking at ways of retaining students in times of dwindling enrollments have turned to tools taught in First Year Experience (FYE) courses as a way to help students adapt to higher education. As a part of the University of Connecticut FYE program, special class sections of a University Learning Skills course were aimed at Engineering majors. Essential study skills aimed at providing students with the tools necessary to bridge the gap between high school study habits and those needed for success in rigorous programs like Engineering in college are discussed. Data on retention of students enrolled in pilot offerings of the University Learning Skills course is presented. Suggestions for a freshman level Engineering course aimed at student adjustment to college with the ultimate goal of promoting solid fundamental study skills needed for success in follow-on Engineering course work is given in the paper.

Introduction: Today's College Students

Each year students enter higher education with questions such as:

- "Will study habits that worked in high school also work in college?
- With heavy academic demands, will I have time for activities other than studying?
- Won't such outside activities hurt my grades?
- What if I don't do well in my courses – can I get some help?
- What if my roommates are very different from me?"[1]

Uncertain of what higher education has in store for them is only natural. However, in recent years the academic preparedness of students entering higher education has shown a shift away from those of the '*academic*' subculture (the undergraduate student subculture of serious academic effort) to that of the '*collegiate*' subculture (a world of football, fraternities and sororities, drinking, and campus fun; indifferent and resistant to serious demands from the faculty for an involvement with ideas and issues.) [2] As a result, students need to be exposed to skills that will enable them to survive the rigors of engineering study.

While the lack of preparation/motivation of students may be debatable, unlike decades earlier most students today take five to six years to complete the engineering degree, if they are of the lucky few that survive the hurdles along the way. It can be surmised that today's students may be different from those of earlier generations, or at least may have more demands placed on them, which require a different approach to helping them succeed. In a paper that is now a couple of years old but still seems relevant, Hansen [3] provides an interesting look at demographics of today's college students vs. previous generations. Some highlights from his paper relative to this work are as follows:

- The percentage of high school graduates aged 16-24 in college rose from 47% in 1973 to 65% in 1996.
- The proportion of students attending college part-time grew from 32% in 1970 to 43% in 1995.
- The percentage of 16-24 year-old, full-time college students who were employed rose from 36% in 1973 to 69% in 1995/96. Those working 20 hours or more increased from 17% to 37%.
- In the fall of 1995, 81% of public 4-year colleges and 100% of public 2-year colleges offered remedial programs. Of all first-time freshman twenty-nine percent took at least one remedial course (24% math, 17% writing, and 13% reading).
- In 1997, just 34% of freshmen reported having spent six or more hours per week studying during their senior year in high school, an all-time low (compared to 44% in 1987). In fact, the average student spent only 3.8 hours per week in 1997, down from 4.9 hours in 1987.
- Freshmen increasingly overestimate their own abilities, rating themselves as "above-average" in virtually all academic areas (e.g., 41% of students in 1997 rated themselves "above average' writers, compared with 27% in 1966).
- In a national poll of 15-17 year olds, only 25% said the "ability to formulate creative ideas and solutions" was extremely important and less than 40% said being "able to write well" was extremely important.

Making the most of college

In a marvelous study looking at how students can make the most out of their college experience, Light [1] has uncovered many findings that coincide with goals for 'student success' courses aimed at the transition from high school to college. His findings [1, 4] include:

- ***Learn outside of class***. The most important and memorable learning experience does not occur inside the classroom. Learning outside of classes, especially in residential settings and extracurricular activities such as the arts, is vital.
- ***Get feedback***. Students say they learn significantly more in courses that are highly structured, with relatively many quizzes and short assignments – crucial to this preference is getting quick feedback from the professor. Students are frustrated and disappointed with classes that require only a final paper or project.
- ***Work cooperatively***. Challenging or complex homework assignments that force students to work cooperatively, dividing up the readings and meeting outside of class to teach one another, increase student learning and their engagement with the class. Good advising is important, but more so are activities outside the classroom such as study techniques; e.g., working in small groups outside of class.

- ***Take small classes***. Class size is important: small-group tutorials, small seminars, and one-to-one supervision are, for many, their capstone experience.
- ***Have a mentor***. A ‘mentor’ experience; e.g., mentored internship not done for academic credit, in which students get to create their own project and then implement it under the supervision of a faculty member, provides an effective tool for learning.
- ***Appreciate diversity***. The impact of racial and ethnic diversity on their college experience has a highly positive effect; students learn from others who come from different backgrounds.
- ***Manage time***. Students who grow the most academically, and who are happiest, organize their time to include activities with faculty members, or with several other students, focused around accomplishing substantive academic work.
- ***Write***. Students value good writing and seek ways for specific suggestions about how to improve it. A course with many short papers instead of one or two long ones leads to improved grades since it offers a chance for midcourse correction.
- ***Seek courses with feedback***. Students appreciate foreign language courses due to the way these courses are organized and taught: classes are small, instructors insist on participation, students work in groups, and assignments include lots of written work and frequent quizzes, allowing for repeated midcourse corrections.
- ***Meet the faculty***. Knowing a faculty member makes a student feel more connected to the institution.
- ***Ask for help***. Of those who stumbled academically in their first year, the ones that asked for help improved their grades and those that did not spiraled downward.
- ***Use elective classes wisely***. Rather than just large introductory courses fulfilling General Education Requirements that are needed to complete the degree, take a mix of courses. Those who take required classes along with those the pique their interest in the first year feel more engaged and happier with their major.

The University of Connecticut Experience

Of first-year students entering the University of Connecticut's School of Engineering, their self-evaluation of ability for success is as follows:

	NSC	NC	N	C	SC
Algebra	0%	0%	3%	30%	67%
Calculus	6%	11%	26%	46%	11%
Chemistry	3%	4%	25%	59%	9%
Computer	2%	3%	21%	45%	29%
Physics	1%	4%	17%	62%	16%
Speaking	2%	13%	30%	30%	24%
Trigonometry	0%	3%	13%	47%	36%
Writing	0%	15%	18%	50%	17%

NSC = Not Strongly Confident
NC = Not Confident
N = Neutral
C = Confident
SC = Strongly Confident

Clearly, this shows that their expectations for success are high; i.e., they feel they are more than capable in subject areas important for success in Engineering.

Unfortunately, however, University of Connecticut retention data shows the following:

After *four* years

- 10% complete the degree.
- Almost 30% remain active in pursuit of the degree.
- 30% switch to another major within the university.
- Almost 15% depart for non-academic reasons.
- 20% depart for failure to meet academic standards.

After *five* years

- 30% complete the degree.
- Almost 10% remain active in pursuit of the degree.
- 30% switch to another major within the university.
- Almost 15% depart for non-academic reasons.
- 20% depart for failure to meet academic standards.

What is disturbing in this data is the finding that roughly just *one-third of the University of Connecticut students who start higher education in pursuit of the engineering degree follow through to completion.* Also, roughly *one-third wind up pursuing another career path* within the university, and roughly *one-third depart from the institution for academic and non-academic reasons*.

These are sobering results to say the least. What they indicate is that today's college student *is* different! As a consequence, we need to rethink how we orient these students to higher education; i.e., we need to provide ways to introduce these students to the university in a way that can lead to success. *We need to impart upon them the* ***skills*** *necessary to be successful*.

Retention factors and learning/success strategies

In a look at the factors impacting a student's decision to leave college, Tinto [5] provides a longitudinal model of institutional departure that has the following components:

- *Pre-Entry Attributes*: those due to family and community background, intellectual and social skills, and prior schooling.
- *Goals/Commitments*: individual commitment toward goal attainment, to the institution to which they gain entry, and external commitments.
- *Institutional Experiences*: academic issues, involving performance and faculty/staff interaction, and social issues, involving extracurricular activities and peer group interactions.
- *Integration*: the extent that success is achieved in both academic and social integration into the learning community.

- *Revisit Goals/Commitments*: positive integration serves to raise goals and strengthen commitments; while the lower degree of social and intellectual integration into the community increases the likelihood of departure.
- *Outcome*: a departure decision results if success is not achieved in integration within the learning community.

As given in Tinto[5],

> "Effective retention programs are committed to the development of supportive social and educational communities in which all students are integrated as competent members."

Not surprisingly, the *facets of retention that engage a student with the university are also ones that enable the student to make the most out of his/her college experience; i.e., the factors influential in retaining students are the same as those aimed at learning.*

Learning Skills for Engineers

It has been known for some time that a First Year Experience (FYE) orientation course has an impact on the ability of students to succeed in college. Upcraft & Gardner [6] provide a nice summary of the FYE movement. Landis [7], is an advocate of providing an orientation course for engineering students as a way to make them successful in pursuit of the engineering degree.

Knowing the 'smart' way to approach academic and personal challenges can make a big difference in the undergraduate experience at a university. University Learning Skills (ULS), an optional First Year Experience (FYE) one-credit orientation course, was established at the University of Connecticut six years ago in an effort to help students modify their high school study habits to those needed for success in college.

Data on retention at the University of Connecticut shows an alarming figure of 20-30% of engineering students departing after the first year. The high number of students who either have academic difficulty or decide to change careers prompted the creation of the ULS course.

The ULS course includes material on study skills such as time management, the Cornell note-taking method, and the SQ3R approach to textbook reading. It also introduces students to engineering facilities and university offices such as counseling services, career services, library, etc. Improved retention of these students who take the ULS course has occurred.

As part of the First Year Experience course offerings for first year students at the University of Connecticut, a special optional course section for engineering majors has been offered during each of the last six fall terms. The course is offered for one-hour, once a week, with class sizes over the three years ranging from 15-75 students. Participants in the course over the years have included those who self-select, those for whom the course is highly encouraged (women and minority students), or those living in particular residence halls.

The course outline is given below. As indicated, there is an emphasis on providing study skill 'tools' up front, followed by an introduction to university facilities along with engineering departmental-specific facilities.

Week	Topic
1	Overview/Learning Styles
2	Lecture Notes: Cornell method
3	Time Management/Goal Setting
4	Textbook Reading: SQ3R method
5	Career Fair/Career Services resources
6	Exam Preparation/Study Groups/Exam Feedback
7	Mentors/Engineering Student Societies
8	Stress Management/Counseling Services resources
9	Library resources #1
10	Library resources #2
11	Exam Educational Objectives
12	Diversity
13	Engineering departmental tours
14	Final exam preparation/review

There is no text for the course, since most of the 'college survival skills' texts on the market do not focus solely on skills or tools, but instead cover additional material often found in a three-credit FYE orientation course. Of the texts on the market, the work by Pauk [8] serves as nice reference. Engineers tend to be focused students in search of tools to put into practice and less concerned about 'wellness' material often found in other books.

Students in the course are expected to

- Attend class
- Prepare weekly one-page ‘journal entries’ in response to a question on that week’s material
- Complete infrequent self-exploration exercises
- Use email
- Attend the Career Fair
- Attend a meeting of the student chapter of the professional society associated with their major

Students earn a letter grade in the course, unlike some orientation courses elsewhere which are graded on a pass-fail basis. The course carries one academic credit and the workload in the course primarily revolves around the weekly writing of ‘journal’ entries; i.e., the workload is kept to a minimum due to the one-credit nature of the course.

The emphasis of the course is one of providing tools or *skills* to the students that they can put into practice to help them bridge the gap between high school study habits and those needed to be successful in college. Skills covered include:

- *Learning Styles*: In addition to learning a bit about themselves via use of the Myers-Briggs Type Indicator, an overview of learning styles based on the work of Felder and Silverman [9] is presented. The key here is to make the students aware that each is different, each has preferred learning modes, that instructors may or may not teach to their preferred mode, and to be aware of this possible mismatch. It is also important for the class to share where each falls on the Index of Learning Styles so that they see many different personalities pursue engineering as a major.

- *Cornell Note-taking Method*: The importance of note taking and the ability of the student to stay in an 'active mode' of learning throughout a lecture period are discussed. Beecher [10] indicates that reviewing lecture notes is an effective learning strategy. This notion of review is a critical component of the Cornell Note-taking Method, which is summarized in an appendix. Students are asked to implement this style of studying from their notes throughout the term. Some find it time consuming and revert back to their earlier ways, others adopt it and benefit immensely. Adopting Cornell is not critical if the students learn the benefits of *continual review* so that they connect one lecture to the next.

- *Time Management.* Consider the typical college student as described in [11]:

  > "As the fall days shorten, as course assignments grow, students develop circadian rhythms. We have no time to study, they explain. Lecture, lunch, and then the soaps – can't miss the soaps – segue so quickly into afternoon sports practice and activity meetings that serious work, at least during the day, is out of the question."

  This scenario seems atypical, but perhaps it is not. Most students are amazed to find out how much time they waste between classes doing little things; e.g., walking back and forth from their residence hall rather than just find an empty classroom to read or do homework problems between classes. Students need to unravel the myth that they need to study to 3am in order to be successful in engineering by instead learning how to use their time throughout the day efficiently and to plan for upcoming events. Creating a 'master schedule' and from it each week a 'weekly schedule' helps students begin to manage their free time and to plan appropriately when projects and exams get assigned. [Comment: in recent years successful students seem to be using a monthly planner to keep track of their commitments.]

- *SQ3R Textbook Reading Method*: A method that forces the student to *actively* engage the material being read and to review it after reading. It is also summarized in the appendix. This technique centers around the need for continual review, but also contains the concept of surveying first where you are headed prior to embarking on the task of reading so that you *actively read* to answer questions posed during the survey so in order to place what you read into perspective.

- *Exam Preparation*: Students are exposed to Bloom's six levels of learning [12] to show them how examination questions can go beyond the simple recognition and recall questions that they may be accustomed to from high school to that of application, analysis, and synthesis questions which require them to think at a higher level; i.e., college is *higher education* at a level above that of high school.

- *Stress Management*: Using personnel from the Counseling Services office, students are exposed to the concept of stress; especially to the notion that some stress is beneficial. Students learn techniques to deal with stress such as the Relaxation Response and the Count-of-Three method [8].

- *Study groups*: Students are exposed to the concept that studying in groups can be beneficial. While collaborative and cooperative learning occurs sporadically in their curriculum, the notion of learning from their peers is stressed. Often students are engaged in team projects in other courses, so the notion of working on a team is not new. However, the concept of preparing for exams, sharing insights on problem solving, relying on each other to fill holes in their knowledge base, etc. is often new and different to many who were under the impression that they have to 'do it on their own' if they are to be successful.

- *Exam Feedback*: As pointed out in [13], students need to seek feedback on how they solve problems.

> "Practice makes perfect *only* when you have information about how well you are practicing. In fact, if you have no way of knowing how well you are doing, practice may serve merely to entrench poor or imperfect actions. … Practice without feedback is of little value."

  Students are advised on how to seek feedback regarding their problem solving techniques. They are also informed how to calculate their grade point average, often a mystery to the majority of the class, as well as how to interpret a curved grading scale; e.g., "I got a 55 and that was around the average so is that a C?"

After the 'tools' associated with note taking, textbook reading, exam preparation and stress management are presented to the students, and after they have tried them for a while, the course shifts its emphasis to an orientation to facilities and support services. Often, this includes topics dealing with issues confronting the students at that point in the term; e.g., stress-reduction techniques around the first exam, course selection around registration time, etc. The material covered includes:

Connection with University: Presentations by Career Services, Counseling Services, and Library personnel help acquaint students with support services.

- *Career Fair.* Students are required to tour through the annual Career Fair and observe the upper-class students and employers to learn about which companies recruit what type of engineers. A follow-up lecture with a representative from the Career Services office then helps place what the students see in perspective. Students are exposed to the qualities recruiters say they look for in the "perfect" engineering candidate: technical skills, hands-on experience, communication skills, leadership skills, teamwork abilities and the ability to be flexible to job demands [14]. Too few realize that more is needed beyond a good gpa.

- *Counseling services*: A representative from Counseling Services appears around the first set of exams and helps the students with test anxiety as well as stress reduction; often just learning that what they are experiencing is 'normal stress' makes a big difference to the students. Students are made aware of the counseling services available to them should they need help dealing with issues ranging from test anxiety to roommate woes or homesick blues.

- *Library*: Two class periods are held in the Library to expose students to the facility and, more importantly, to computer search techniques used to find information. Students are given a task in the first week to search for a topic/book/article using the search engines and then in the second week they are asked to locate the book in the library. Forcing the students to seek the item that was found on the computer search demystifies the library and is far more useful than a tour of the building.

Mentor/Connection with the School of Engineering: Students are introduced to the leaders of the student societies and are encouraged to join the professional society in their major. Students are also toured through facilities associated with each major; in an effort to acquaint them with the school. The departmental tours provide a look at laboratories, senior projects, sophomore labs, etc. so that the students get an idea of what type of work they may be doing in subsequent semesters. There is also a limited overview of each major discipline. The key is a focus on *orientation to facilities,* rather than an ‘Intro to XYZ Engineering’, while at the same time providing some information about different disciplines since many of the first-year students are undecided regarding which engineering major is for them.

Throughout the entire term, a unique question and answer technique is used to provide useful advice and *feedback* to the students:

One-minute paper [15,16]: At the end of each class, students are asked to answer the following:

- What is the main point that you learned today?
- What remaining question do you have?

Of these, the one that allows the students to ask a question leads to interesting results. Often the questions asked are on topics of interest pertaining to their residence hall, their other courses, their notion of what engineering is about, etc. These questions are compiled and answered via email prior to the next class. From week to week the students get answers to concerns that they often would not have anywhere else to turn to for a solution or advice.

The optional one-credit ULS course has been offered for six years. Results have shown an improvement in retention after the first year of 5-10% when compared to the non-ULS students. Fewer of the ULS students switch to another major outside of Engineering. Similarly, after the second year, retention data shows more students still pursuing engineering. Overall, an improved retention seems to be obtained.

It appears that the ULS course has an impact. A greater percentage of the students seem to obtain the 'connection' with their major that is important in achieving integration into the academic community.

Student Evaluation of the ULS Course

The following provides a summary of student survey responses at the conclusion of recent offerings of the course:

	SU	U	N	NU	SNU
Learning Styles	21%	53%	20%	5%	1%
Time Management	52%	38%	4%	4%	2%
Goal Setting	31%	50%	15%	3%	1%
Lecture Notes	22%	35%	33%	7%	3%
Cornell Method	15%	38%	34%	9%	4%
Textbook Reading	16%	51%	23%	10%	1%
SQ3R Method	16%	42%	29%	10%	3%
Group Study	14%	43%	30%	10%	3%
Exam Preparation	31%	42%	19%	3%	5%
Career Fair	29%	28%	29%	9%	4%
Student Societies	27%	40%	25%	6%	3%
Career Services	27%	43%	18%	10%	3%
Counseling Services	25%	38%	27%	10%	1%
Library	18%	39%	29%	12%	2%
Engineering Tours	34%	45%	12%	5%	4%
SU = Strongly Useful U = Useful N = Neutral NU = Not Useful SNU = Strongly Not Useful					

Clearly, the evaluation of the usefulness of the material in the course is quite high; i.e., the students perceive a true value added to their educational experience by taking the course. In addition to the ratings on topics covered, 72% said the course met or strongly met the goal of helping them learn and develop a set of adaptive study, coping, critical thinking, logical problem-solving, and survival skills.

Implications beyond the First Year

The success of the FYE course in regard to keeping students in pursuit of the engineering degree is noteworthy, but at the same time not ground breaking. Many successful adaptations of the FYE concepts into 'orientation' courses have occurred throughout the country. Some of the material covered in the course may be found in more traditional ‘Intro to Engineering’ classes in which students work in teams on problem solving activities.

What may be of more interest is adapting the notion of imparting appropriate *skills* for success in later courses as needed. Consider the instructor who is developing *instructional objectives* [17] for a course. The instructional objective must

1. Describe what the learner will be doing when demonstrating that s/he has reached the objective; i.e., *What is the learner to do?*
2. Describe the important conditions under which the learner will demonstrate his competence; i.e., *Under what conditions will s/he do it?*
3. Indicate how the learner will be evaluated, or what constitutes acceptable performance; i.e., *What will you expect as satisfactory performance?*

Of these three components of an instructional objective, it is the second one that relates to the teaching of “skills” that students need in order to learn successfully.

Consider the work of Light [1] again. Students who make the most out of their college experience are ones who:

- Learn outside of class
- Get feedback
- Work cooperatively
- Have a mentor
- Manage time
- Write
- Meet the faculty
- Ask for help

It seems quite reasonable then, to not only develop instructional methods addressing learning objectives, but also address and teach the *skills* needed to achieve the level of learning expected. In other words, when making assignments for students, consider teaching them the tools to accomplish the task as well. Teaching skills, not only in the first year, but in later courses as the conditions for learning change with increasing levels of competence, can only result in more successful students who learn the material and make the most of their college experience.

Conclusions

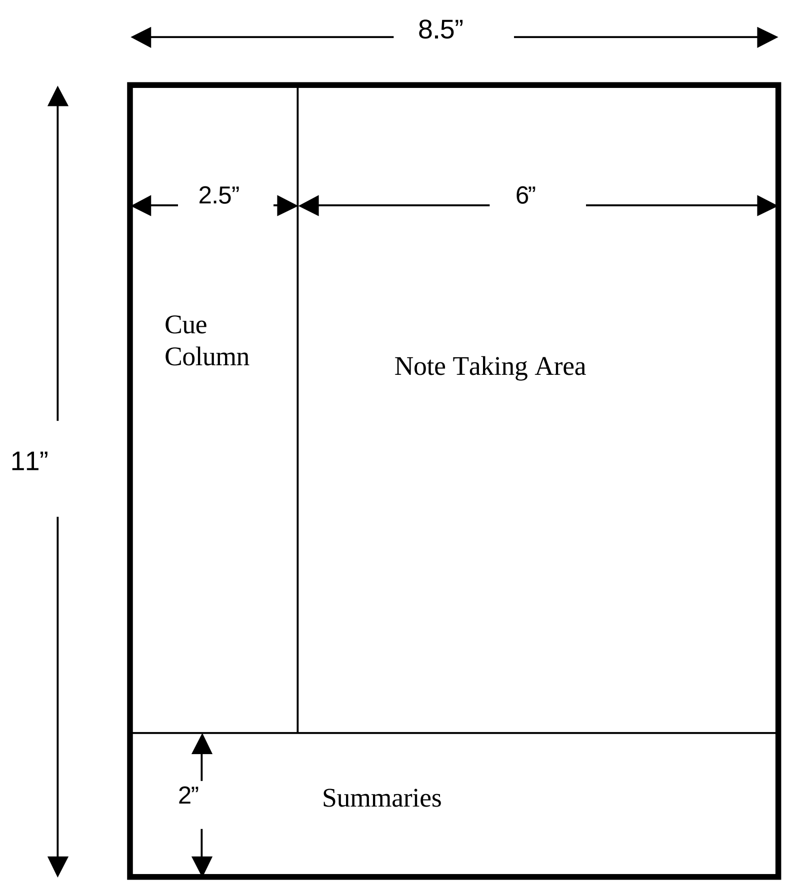
Given that today’s students in college seem to be different from those of earlier generations, a concern about their ability to be successful in adapting their study behavior to the rigors of the college environment prompted the development of a First Year Experience University Learning Skills course. This optional one-credit ULS course has been offered for several years and has shown to lead to an improvement in the retention of students in engineering. Roughly 10% more of the ULS students are retained after the first year when compared to those not taking the FYE ULS course. The improvement in retention resulting from the FYE ULS course is anticipated to improve the percentage of students entering engineering who complete within a four or five year period.

Learning skills in the first year that can be used to be successful in later courses and having teachers develop learning objectives with skills in mind may help students make the most of their college experience.

Appendix 1: The Cornell Note-taking Method

The Cornell method involves dividing a page of notes in the format shown and following the steps below:

1. Record the lecturer's ideas/facts in the *note-taking area*.
2. At your next free period, read over your notes to fill in gaps.
3. Determine the first main idea; then in the *cue column* write a question based on the main idea.
4. Block out the *note-taking area* with a sheet of paper, read the questions in the *cue column*, recite the fact needed to answer the question; repeat until the idea is mastered if not gotten the first time.
5. At the *summary area*, write a concise summary of the page of notes; this summary makes studying for exams efficient.
6. Review your notes immediately so that you can end up with a view of the whole rather than isolated facts and ideas.
7. Reflect on the facts and ideas contained in the notes.



Note Taking Area: Record lecture as fully and as meaningfully as possible, using a style you are comfortable with.

Cue Column: As you are taking notes, keep the cue column empty. As soon after the lecture, reduce your notes to concise jottings as clues for Reciting, Reviewing, and Reflecting.

Summaries: Sum up each page of your notes in a sentence or two.

In summary, the Cornell Method provides an opportunity for putting into practice the five R's of note-taking: Record, Reduce, Recite, Reflect and Review.

Appendix 2: The SQ3R Method for Textbook Reading

The SQ3R system was devised during WWII to help military personnel enrolled in special programs at a university to read faster and study better. It involves the following, for which it gets its name:

> *S = Survey*: Leaf through an assigned chapter reading headings and subheadings, skimming topic sentences, and reading summary and concluding paragraphs.
>
> *Q = Question*: Turn headings and subheadings into questions by preceding them with who, what, when, where or how.
>
> *R = Read*: After a question is framed, read the ensuing paragraph or section to answer the specific question.
>
> *R = Recite*: Immediately after reading, look away from the page and recite what you have just read in your own words.
>
> *R = Review*: After finishing the chapter, go back to the beginning, glance at each heading and mentally note the contents.

As with the Cornell system for note-taking, the SQ3R method forces the student to actively engage the material being read and to review sufficiently so that the material becomes learned.

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