

The Elements of Successful Study in Engineering

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Foreword

The sine qua non for successful study is to realize first that learning is living -- that study for the joy of learning marks the difference between man and animals! The beast in the field studies how to obtain food and shelter -- and then goes to sleep happily until hunger again rouses his thought processes.

Man is marked by the desire to learn that may take many forms: how to build a new house -- how to bowl or play golf -- how to master thermodynamics. If, by the time you graduate from college, studying engineering or science or mathematics is a constantly disagreeable chore, the chances are great that you are in the wrong field!

The successful bowler, or engineer, or scientist, or husband loves his work, and loves to study problems that arise in his work! (And this "love" has many "quarrels", of course.)

On the other hand, you may be studying a subject in the hope that it will fit into your work. At this stage the subject is neutral to you. If you are an undergraduate you may be faced with seven courses to be "loved" at the same time! (And we call seven courses at a time, or even five or six, education! Bah.) Or you may be working on a job that requires intense concentration for most of your waking hours. Under such circumstances, it is desirable to first study the art of learning. More generally, to study how to encompass many things into the hours that you have available.

The following presentation should prove to be a useful aid in developing an individual system of study. To obtain maximum benefit, it should be read and re-read. Then, it is suggested that the reader prepare a Review Outline which presents the highlights of the article (this might be done simply by underlining). The outline could then be used for (relatively frequent) future reference, to serve as a reminder and check-list.

Refer also to 'discipline sheet', handed out 1st day of class.

The Elements

The necessary elements of fruitful study (not necessarily in the order of importance) are:

1. Organization (including methodology)
2. Time Budgeting
3. Concentration
4. Diligence
5. Motivation
6. Rest

The common goal of this set of factors is the economic use of time; to elaborate on each of these items:

1. Organization for study may be separated into two types:

(a) Evaluation; that is, development of "Utilization Plan" for organized use of the available study aids (textbook, lecture notes, homework problems, instructor, discussion section, laboratory, etc.). This should evolve rapidly at the beginning of each course, and then be modified continuously as found necessary. At the beginning of a course, for example, one must assess whether he should rely mainly on the notes taken from lectures, on the textbook, on reference books, or what-have-you for learning the required material -- "required" by the particular instructor. Also, what is the place of the homework problems in the instruction? Are the problems mainly teaching aids to help understand the theory? Are they mainly illustrations of how the results of the theory are applied? Or are they combinations of these? Another important question: To what extent will the instructor emphasize theory, and to what extent practice, on the examinations? All these things must be evaluated, consciously or subconsciously, in developing a "Utilization Plan" for the course.

(b) Methodology; that is, development of a system of study for the course -- a standard sequence to be followed on each major topic. Again, this should evolve early in the course. One obvious arrangement is that problems should not be attempted until one has attained sufficient confidence in his understanding of the theory. To elaborate, and clarify the intent of sufficient, after beginning work on a problem set, one should not continue working if he feels as though he is "stabbing in the dark" -- if he is selecting equations from the text (or notes) without really understanding "why that equation", or if he is doggedly following, without

understanding, example problems in the text. The existence of these remarks is that a mere answer to the problem is seldom (probably never) the goal. Therefore, one must be precise in devising a logical step-by-step procedure for attacking the problem, and he must be precise in illustrating (by pictures, equations, or whatever is necessary) this procedure; precision in numerical answers is secondary.

But how does one organize the remainder of the overall sequence, preceding and following the problem-solving? By answering the following: Does it appear that reading from the textbook should precede attendance at lectures? If so, should this reading be a careful reading, with emphasis on detailed understanding, or should it be of a preliminary (preview) sort to survey the entire domain, without great concern for understanding of all the details, to be followed after the lecture by careful reading? The latter approach might be wise since the lecture can then serve as a guide to show what parts of the reading are most important -- where detailed understanding is necessary. On the other hand, the student might forego reading completely until after the lecture, using the text as a reference for more detail on the various topics in the lecture. If the lecture notes play a predominant role in a particular course, then they should definitely be rewritten in order to polish and organize the class notes. This should be done immediately after class when the lecture is fresh in the student's memory, and so that those comments that were not put on the blackboard and/or were not copied down can be included in the recopied notes. Also, the notes should be recopied in the presence of a suitable array of reference books, perhaps just one book, perhaps many to amplify questionable areas. Before departing from the topic of reading, what are good reading habits for studying of technical (versus liberal) subjects -- whether it be reading of books or notes? First skim the material, then proceed with the intent of understanding each step in the development of the material. When a seeming "immovable object" is encountered the following techniques for getting through:

- (1) Try to frame (in writing) a specific question for the teacher; in so doing the answer often becomes obvious!
- (2) Review the material preceding and then read one step (or a few) ahead; then, try to fill the gap (perhaps in writing).

(3) Fight.

When the light finally dawns, then quickly review "all" that preceded because during the relatively long time interval that passed during this encounter, much of the preceding material will have faded. (From this discussion, you can see that you should always have a pencil in hand when studying.) Another important and, really, obvious part of a good study sequence is continual review, to all levels. This should be done for many reasons. First, it helps the student to assimilate the different topics -- necessary for complete understanding. Second, it makes reviewing for an examination almost casual. One should never be in the predicament where he must cram; under such conditions the nervous mind cannot assimilate--things do not fall into place--and the material to be covered seems to be a garbled collection of unrelated "facts". Really, the message of this whole essay on Methodology is that the mind will not be able to organize everything that is fed to it, unless there is a logical sequential approach.

2. Time Budgeting. At the beginning of each week, day, and study session the student must plan on how and in what proportions that period of time will be utilized. How much time will be devoted to each course; how will the time for each course be subdivided into reading, doing problems, and reviewing? This scheduling must be continuously revised because, almost invariably, more time will be used on some item than that allotted initially. One might ask, "If you admit you are not going to live up to your schedule, why have one?" The answer is that such a schedule keeps before you the work you must accomplish, and the schedule gives goals to be aimed for.

The principal criterion upon which the time schedule should be built is this: "At no time during any course will I get behind." This is a must. It means that in preparing the schedule one must foresee events which will disrupt the schedule by requiring a large amount of time -- things like exams, etc. For example, to assure that one does not fall behind in other courses while studying for an exam, he must get ahead in all courses so that by the end of the exam he at least breaks even. It is a good idea to get ahead even when no such event can be foreseen, because something unforeseen will occur: "I don't have to study tonight but I think I will because maybe there will be something I want to (or have to) do tomorrow night".

3. Concentration. Repeating, all the items in the list of study elements together have a common aim: economic use of time. The present item is the first prerequisite for attaining that goal. Without intense concentration on the immediate job, be it studying or anything else, the work drags on and on. We all realize that if we spend half our time "on-th-job" and half our time daydreaming that we can accomplish much less than half of what we would do with complete concentration on the job. So, especially when studying, one should endeavor to reach complete concentration, to shorten the task (and allow time for study of other courses and for outside activities). Every minute the mind wanders increases the required learning time by many more minutes.

Today, the "refreshment break" is probably the most abused policy in existence (whether it be company policy or personal policy). It serves as the basis for our most extreme rationalizations. When one is studying, or doing any kind of work, and he feels like taking a break, he shouldn't. Instead, he should choose a sizeable amount of additional work with a logical stopping place and say, "When I complete this, then I will take a break." The correct size of this additional work is quite crucial; it should not be so long as to create a frustrating restlessness, nor should it be as short as you would like to rationalize. Another trick to combat this sort of restlessness is a temporary change of position, say from the straight chair to a stuffed chair but be sure to keep in mind that this change of position is just for the sake of change, not for a rest. This serves two purposes, it not only avoids wasting time but it also provides motivation (item 5).

Another important factor for successful concentration is appropriate working conditions. The first item that should be mentioned here is quiet; noise, always distracting, cannot be tolerated. And the best students realize that, for study purposes, even soft music is distracting. There is only one excuse for having soft music: as a low-level continuous sound, in itself pleasing, for disguising unavoidable background noise. This does not admit that soft music is acceptable, only that it is the least objectionable. Not only must noises-whose source does not intend them-to-be distractions-be avoided, but so must interruptions be avoided. The study place must be secluded, because interruptions in the middle of a train of thought are frustrating. The whole sequence of logic must be repeated, and somehow it always seems to take longer the second time. Other working conditions to be mentioned are good lighting, a large desk for spreading out material, a good straight-backed chair, good ventilation (and in winter keep the room cool).

4. Diligence. To carry out the procedures indicated by these study elements, one must be dedicated to his studies. He must declare to himself that he will do a complete job of learning the required material, and learn to enjoy it. Once a student experiences mastery of his studies, then he comes to enjoy the intellectual challenge; his ego now gives him the desire to learn. This persistence is not the only aspect of diligence. Another is the resistance of distracting temptations. The good student is unwavering by the beckoning of friends (or relatives, or television) to "take a break". He is able to overcome the fear of being classified as an oddball, or as ambitious, or what-have-they, realizing that such classifications are just their rationalizations. Too, the temptors are soon trained not to bother.

Here is probably the best place to discuss the value of "bull sossion" in learning. In general they are useless wastes of time and result only because everyone wants to believe the sessions are useful. Make it a policy to avoid general discussions, unless you have a specific question to ask or are approached with a specific question.

5. Motivation. This is believed to be one of the most primary, if not the most, of all the study elements. It works in many ways.

First, human nature being what it is, in order to be dedicated to his studies a person must feel a valid reason for them. Without this, all is hopeless. It can be said flatly that one should not waste his time studying a subject if he doesn't believe there is some good reason to. This reason might vary from one extreme, the realization that the material is fundamentally important to his future undertakings, to another extreme, perhaps only the fact that the course is required in the curriculum being pursued. (If the latter reason is not sufficient to motivate a student to do his best, then he probably should not be in school.)

Just as important as the above overall motivating reason are others, short-term motivations. To provide a reason for accomplishing all the work on this week's, or this day's or this evening's schedule in the allotted time (as closely as possible), these short-term motivations are necessary. Rewards serve as the best short-term motivations. For example, whenever drafting a time schedule there should be no time definitely allotted for extracurricular recreational activities. Rather, while drafting the schedule, the extra time left over should be considered a "cushion". Then, the realization that the extra time not required to serve as a cushion-not required as a supplement to allotted times which proved to be too short-may be used to do "what I darn well please without any qualms about wasting time". This serves as an excellent motivation to be efficient. Such a reward technique is very highly recommended (by one of us); it works best when one tries to accumulate extra time, say for "a free weekend."

6. Rest. It is an absolute necessity for every person to determine the amount of rest that he requires, and then consistently get that much. It is bad economics to short-change oneself on sleep; the work accomplished during those extra waking hours is less than the total work lost in a day because of the resulting decreased effectiveness. Too much sleep is just as bad as too little-worse, because it means sloth. It is easy to mistake boredom for sleepiness. If you feel sleepy at a relatively early hour plan a "break" and do something like (1) have a cold drink of water, (2) splash cold water on the face, (3) open the window and deep-breathe some cold air, (4) exercise or shadow boxing, (5) a brisk walk or run.

Concluding Remarks

The reader has probably already concluded that the principles set forth here are impossible to live by, that such a degree of perfection cannot be attained except by an inhuman machine. Perhaps, but the purpose of this presentation is not to elicit what a person must do to be a successful student, but what he must strive to do. The purpose is to point out the ways a student must discipline himself. The purpose is to show that a student must continually apply psychology to himself, in a number of different regards; each individual must determine the particular techniques required, for his personality and physical make-up, to live up to the elements listed and discussed herein. The purpose is to show that learning is almost completely a do-it-yourself project, and that it can become enjoyable. Probably the principal goal of formal education is to teach the individual to be able to make learning completely do-it-yourself -- especially important for the professional man: obsolescence.

If the reader has concluded that this paper is one of those things that should be taken with a grain of salt, then there is no hope for him unless he changes his attitude. This presentation is for the student's sake; its goal is to make his life easier, not more difficult, by helping him to study more effectively and thereby learn more in less time. Also, do not say it is too late to develop good study habits; some of the best students have been those who "woke up" after high school, after undergraduate college, or even later. If one says it is too late now to learn how to study, he may be burdening himself with a tremendous handicap; learning is a part of living.

In any case, the student should make a conscious effort to employ and perfect all aspects of the elements presented here. He will know he is succeeding when these conscious efforts become more and more innate. If the student cannot improve via these techniques it is because the proper motivation is lacking, not because ability is lacking, and he should change his goals.