Learning 101

A STUDENT GUIDE TO EFFECTIVE LEARNING

prepared by:

Wm. J. Garland, Professor
Department of Engineering Physics
McMaster University
Hamilton, Ontario
Canada
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prepared for Engineering Students

TABLE OF CONTENTS:

LISTS:

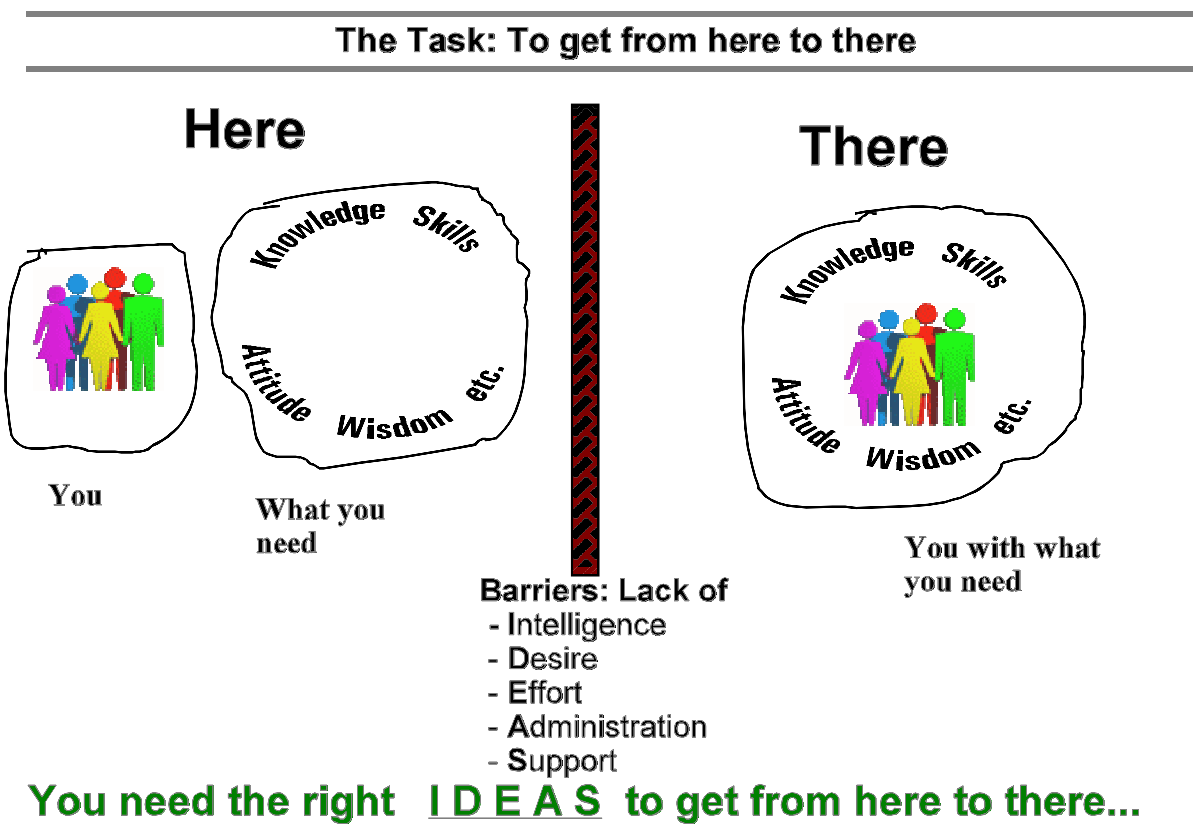
Towards Effective Learning

1 The Task at Hand

Whenever one sets out to present a subject to someone else, some fundamental questions must be addressed:

Who? What? When? Where? How? Why?

"When?" and "Where?" are given by the university schedules. "Who?" is a "given" here: Engineering Students. The "What?" is the course at hand. You need to acquire knowledge, skills and the mindset appropriate to the topic and your needs. Learning is not a trivial task; you'll need a number of things to successfully learn the material at hand - namely: Intelligence, Desire, Effort, Administration and Support.



2 Prerequisites for Effective Learning

Here is a checklist of some rather obvious items you need in order to learn.

- **Intelligence**
  - supplied by student
  - a result of genetics, good upbringing, health, food, rest, exercise
  - peace of mind
    - ability to concentrate, tune out other things
    - greatly enhanced by setting priorities and allocating time slots
    - depends on generation of self esteem (as per Maslow)

- **Desire** (Motivation)
  - student supplied but enhanced by a hygienic environment
  - spirit of inquiry: supplied by student
  - ask questions - study then becomes an inquiry with motivation
  - compare this to computerized learning-question/answer process
  - subject must be considered relevant by student

- **Effort**
  - supplied by student
  - put the time in
  - incentive is for efficient and effective use of time
  - study habits.

- **Administration**
  - material must be available: supplied by bookstore, library, teacher
  - location: classroom, study areas, etc.
  - class structure and teaching format

- **Support**
  - guidance - supplied by teacher
    - to provide objectivity, experience, reflection and generally to enhance process, diagnose problems, correct misconceptions, provide measure as a guide for the students (tests are important but they're not everything).
  - background experience to relate to
    - supplied by student, personal experiences, other courses - enhanced by practice and the habit of the student to integrate experiences
  - positive reinforcement - marks, peer group
  - timely reinforcement - instant feedback.

In short, you need the right **I-D-E-A-S**.

3 Concepts of Learning

3.1 The Concept Map

People differ greatly in their ability to abstract and otherwise think. It would be the rare exception, however, who did not learn from the bottom up, from the particular to the general. Figure 3.1 illustrates the notion of knowledge bits on the level of *facts* that the student learns about through direct experience and association. After the bits are assimilated (ie, the student can regurgitate the facts), it is possible to cluster the facts into groups, or knowledge islands to form a concept. This is the process of abstraction. The student should now be capable of viewing the knowledge domain from the top down as well as the bottom up. The clustering process provides a structure for recall and use of information; the *concept* is the memory recall tag. It is efficient and it is effective. The currently accepted model of cognition is that long term memory serves as a vast data bank. The stored knowledge and input stimuli are processed in short term memory. Some people are capable of processing up to 9 isolated bits of information in short term memory; the normal range is 3 -7 items. It is not a coincidence that number sequences like telephone numbers are clustered in groups containing 3 to 4 numbers. We conclude from this that clustering is not only efficient and effective, **it is necessary**. The student (or anyone else for that matter) could not possibly handle anything but a trivially simple situation without abstraction. Understanding is required. There are simply too many situations to remember and recall. Hence we must interpolate and extrapolate from the known. To do this we must abstract.

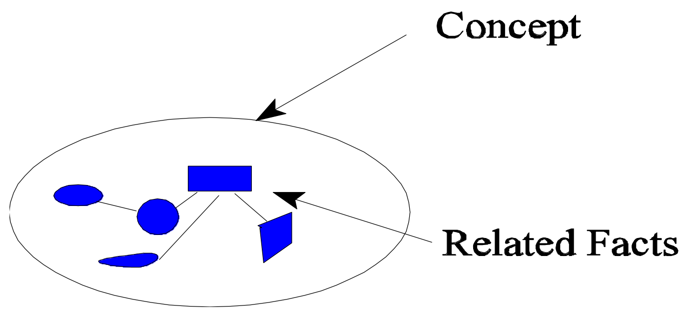


Figure 3.1 Clusters of related facts form a concept

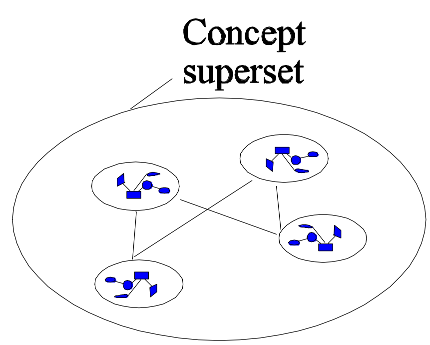


Figure 3.2 Related islands of knowledge form a higher level concept

The cluster becomes a bit of knowledge to be related to other clusters, thus forming a higher level concept, as illustrated in figure 3.2.

While we learn from the bottom up, once the hierarchy of concepts have been formed into a framework of cognition, a proficient student should be able to draw on this framework as the situation dictates to demonstrate that he/she can conceive of the situation, the issues, possible solutions, selection criteria, the path forward, and so on. Typically, these demonstrations or explanations take on the form of words, graphs, equations and illustrations. These are all special forms of a general construct called the CONCEPT MAP. The figures in this document are examples. **Since abstraction is required for a proper Student response (since all possible situations cannot be enumerated, let alone remembered) and since concept maps are expressions of abstraction, proficiency in the use of concept maps is a quantifiable and meaningful measure of student cognitive ability.**

Concept maps can be constructed for discipline areas such as mathematics, physics, etc. And, of course, concept maps can be constructed in a variety of ways, across disciplines, for example nuclear engineering draws on concepts from mathematics, nuclear physics, metallurgy, etc. These frameworks are constructions of convenience; groupings are not unique and a concept map constructed for a student novice may look quite different from that for an expert. The form follows the intended use.

3.2 The Cognitive Domain

Bloom [BLO71] et al have formulated a hierarchy of the cognitive domain with six distinct levels as follows.

- 1 Knowledge
- 2 Comprehension
- 3 Application
- 4 Analysis
- 5 Synthesis
- 6 Evaluation.

Appendix 1, reproduced from an in-house McMaster University course on *Course Design*, provides some explanation of each of these levels. Note the action words in the right hand column. These words have been carefully selected to characterize the cognitive level. We can use these action words to formulate training objectives. Furthermore we can use the levels to characterize the training objectives for the purposes of evaluation - of both the student and the program.

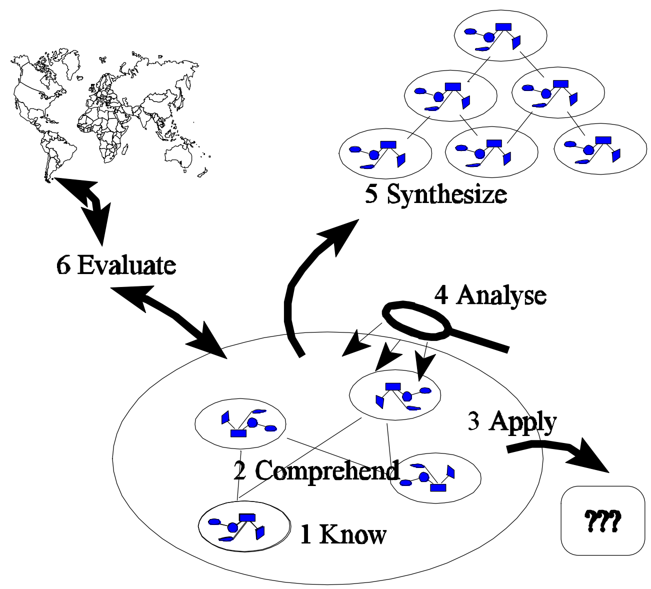


Figure 3.3 Concept map of Blooms hierarchy if the cognitive domain

We have already met the KNOWLEDGE level. This is the level of basic facts that must be recalled to some specified degree of fidelity. Multiplication tables must be recalled precisely; properties of water need only be known approximately, etc.

The knowledge facts and clusters of knowledge facts (concepts) are COMPREHENDED on the second level, that is, there is an understanding of the concepts and connection between the concepts within the narrow domain (the large ellipse of figure 3.3). At this level the student is not expected to be able to extrapolate outside this narrow domain.

The APPLICATION level, however, entails the use of the knowledge and comprehension in the solution of some application that lies outside of the learned domain. This implies being able to determine when to use acquired knowledge and skills, not just how to use them.. The applications are on the level of "plugging in the numbers" although this understates the real cognition required.

The ability to ANALYSE is the ability to appreciate and understand the relationships of the concepts within the domain. This is a *picking apart* activity to see how it works and why it works.

SYNTHESIS is the ability to recombine the pieces resulting from analysis and the other lower cognitive levels into novel arrangements.

Finally, the ability to EVALUATE is the ability to compare or judge the knowledge domain (as understood by the other levels) against the outside world (ie against given standards or other criteria).

The level of understanding required of the student can now be quantified somewhat. It is apparent to me that the first three levels are certainly required. Likely, proficiency on the analysis level is also required in most topic areas. Since the reality does not follow procedures and since procedures, even if we tried very hard to reduce reality to procedures, could not possibility cover off all possible scenarios, the engineer will be required to switch from one procedure to a more appropriate one on a regular basis. In addition, if an error was made in the execution of a procedure, the engineer would be required to recover from this error. These situations require analysis, perhaps interpolation of current practice, and, to the extent that extrapolation of current procedures are required, synthesis. Evaluation, or that 'heads up' view of life, would likely be required as a matter of course.

3.3 The Affective Domain

Attitude is equally as important as cognition, yet it is usually neglected. Consider [BLO71]:

> "The reasons for this emphasis on the cognitive in preference to the affective are several and interactive. Our system of education is geared to producing people who can deal with words, concepts, and mathematical or scientific symbols so necessary for success in our technological society....
>
> This is not to imply that the realizations of cognitive outcomes are not accompanied by changes in affect - quite the contrary; these outcomes may be very closely related ... Indeed, certain established pedagogic techniques for producing acceptable cognitive outcomes can destroy any positive feeling a student might have toward a subject area. Suffice it to say that it is possible for a learner to understand and be quite proficient in a subject matter and still have a deep aversion or other negative affect toward the discipline...."

In short, there is not much point in the student being trained in some skill (say ordinary differential

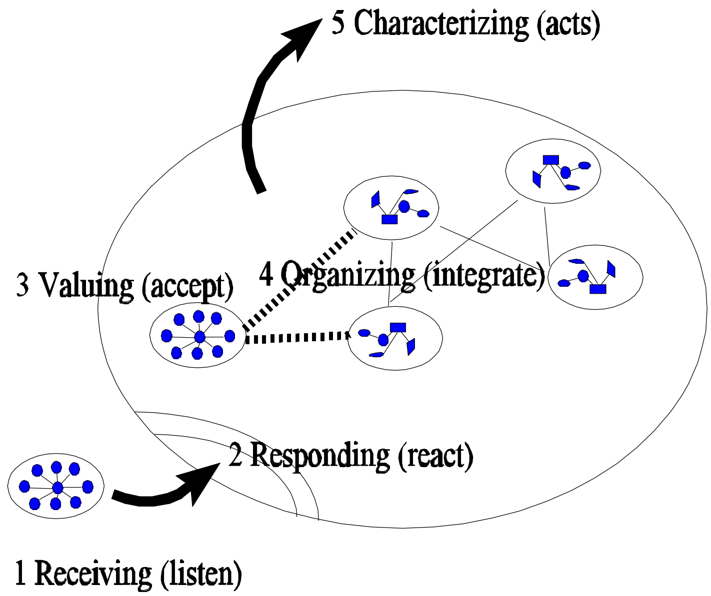


Figure 3.4 Affective domain

equations) if he / she is averse to using the skill when it is required. On a more subtle level, one can comprehend without having a commitment. This can lead to inaction when action is required in the engineering profession. Quite apart from a loss in effectiveness, safety could be compromised. It is important, then, to quantify the affective domain so as to define standards to judge learning outcomes (objectives) by.

In a manner analogous to the cognitive domain, the affective domain is divided into hierarchical levels [BLO71, pp 229-230]:

- 1 Receiving
- 2 Responding
- 3 Valuing
- 4 Organization
- 5 Characterization.

See appendix 1 for additional details. Referring to figure 3.4, RECEIVING is the lowest attitudinal level required for learning. It represents a willingness to receive input. RESPONDING refers to the level at which there is voluntary attentiveness. VALUING implies perceiving the subject matter as having some worth. The student becomes involved. ORGANIZATION is defined as the conceptualisation of values and the employment of these concepts for determining the interrelationship among values. CHARACTERIZATION is the organization of values, beliefs, ideas, and attitudes into an internally consistent system. At this level, the consistent system of ideas are internalized; belief is consistent with the rational (cognitive) side; a commitment to action is achieved.

A successful student will, by definition, have achieved at least the VALUING level. Anything less would have led to failure. It is highly desirable for the student to have reached the CHARACTERIZATION level for reasons of safety, as stated above.

Setting and evaluating objectives in this domain are more problematic than in the cognitive domain. The affective domain is, by its very nature, more qualitative and less quantitative. In addition, the student can easily hide true feelings, thus subverting the evaluation process. Nonetheless, these difficulties in measurement do not lessen the importance of measurement of performance in the affective domain.

3.4 The Psychomotor Domain

One other domain is important for the training of professionals. The psychomotor domain is the domain of the performing of a physical act and is broken down into 7 hierarchical levels in a manner analogous to the other domains, as shown in appendix 1. This domain does not directly apply to the training of science or equipment fundamentals as currently envisioned; however, it is mentioned here as a pointer to another dimension of learning that should be addressed if a laboratory component is added to the courses or if the student is experiencing difficulties that are not identifiable in the cognitive or affective domains. The psychomotor domain is more relevant to the practical exercises such as simulator training and, hence, will not be discussed any further in this document.

3.5 Mental Models

While the foregoing sections delineate the various levels and types of behaviour, they do not address the way people think and solve problems, that is, they do not address the mental models used. Some possible models are:

- Memorization (the density of steam at pressure X is Y times that of liquid);
- Rule based (½ of a radioisotope disappears in one half-life);
- Analogy (xenon and iodine concentrations build up and decay like water levels in two interconnected tanks);
- Mechanistic (the water level rises causing the float to actuate the switch);
- Functional abstraction (Defense in Depth is an effective strategy as an overall safety philosophy and as a teaching methodology since both safety and teaching do not rely on any single strategy for success);
- Mathematical ($dN/dt = -\lambda N$).

It appears, from conversation with engineering professionals and from personal experience as an educator, that the primary mental models used by successful technical workers (on all levels) are the mechanistic and functional abstraction models. They form the basis for the internalization of a subject matter; they permit and guide an internal and external dialogue when thinking through a problem.

The mechanistic model is a quite literal translation of the physical mechanism. Indeed, in most cases, the student has a clear mental picture of the physical device internals. However, this is a necessary but not sufficient condition for a <u>systems level</u> understanding of the function of the device. For that, functional abstraction is required. For example, understanding that towns tend to grow around major transportation routes would lead one to suspect that the city core is down hill from the suburbs in a city with a major waterway. Thus, functional abstraction is extremely useful for charting one's way through a situation. It is this generalization that most effectively compensates for our limited memory. This, in my estimation, depicts what we generally mean when we talk of *understanding* and this is the meaning used in this document. The cognitive and affective level as used herein are with respect to this meaning of the *understanding* activity - that is, with respect to the task of developing <u>mechanistic</u> and <u>functional abstraction</u> mental models.

These are the concepts that the student must learn.

However, this does not mean that mathematics should be ignored. Good pedagogy involves the use of multiple descriptions of the same phenomena from different aspects. The judicious use of the proper level of mathematics has an important role to play in learning in spite of the fact that calculations are not often required in the control room.

The mental model for problem solving proposed by Rasmussen [RAS86] is one that is based on functional abstraction. Rasmussen's figure (reproduced in part in figure 3.5) illustrates this generic algorithm. The generic algorithm for problem solving is to observe and identify the state of the situation, interpret, evaluate, plan actions and execute the actions. Rasmussen notes that shortcuts can be taken at any stage. In fact, most of what we do involves shortcuts to some degree. ALL problem solving is covered by this figure but the technician often employs strategies and tactics that do not rely as heavily on a detailed knowledge of system and component behaviour as might an engineer. That is, the technician cannot usually afford the luxury (time and effort) to travel all the way to the top of the tree and down again to solve the problem; short cuts to Rasmussen's full solution path are taken. This is a form of shallow reasoning. This is not to say that the technician does not have a detailed knowledge of the systems and components. He or she indeed does. It is simply that it is not appropriate to spend days and weeks reflecting on issues that demand rapid responses. As depicted in figure 3.6, the desired strategy for an engineer is the middle road of using a level of abstraction consistent with the time of response required for the task at hand. The “sweet spot” is somewhere between an in-depth, slow analysis and an immediate unconsidered reaction.

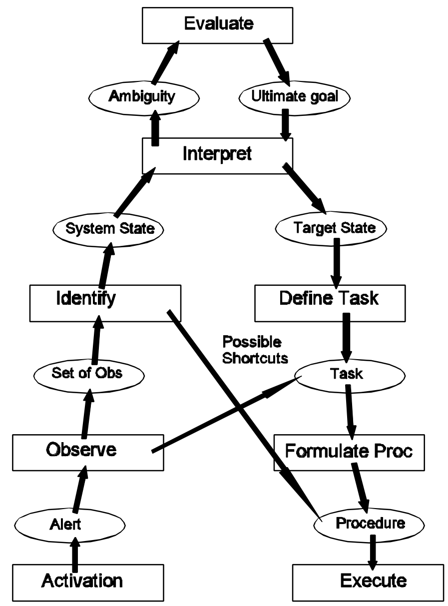


Figure 3.5 Rasmussen's mental model (simplified)

It is essential that the required problem solving strategies appropriate for the Student be delineated. Like mathematical skills, problem solving skills may best be introduced as an integral part of the existing subject matter courses. However, it is recommended that a series of modules devoted to problem solving approaches and techniques be developed so that, at the very least, the developers of training modules have a common point of reference and a resource to draw on.

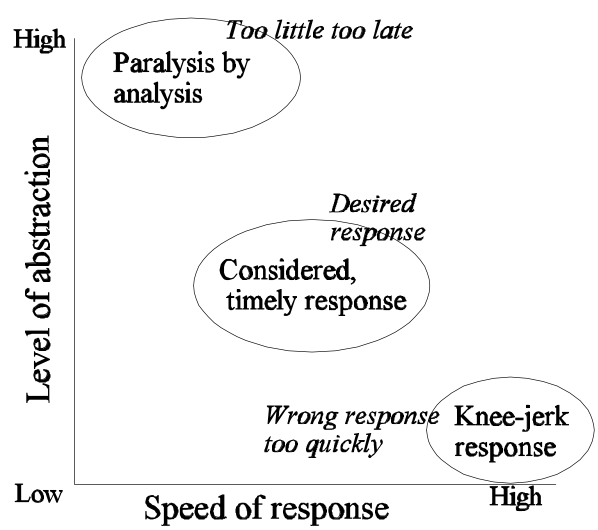


Figure 3.6 Desired response

3.6 Miscellaneous Notes

- Paper maché model
  - layered and built up on previous knowledge

- Must be able to integrate new ideas with old (previous layers).

- The clumping effect
  - cannot relate clumps of information until each clump is mastered.

- Interpolation and extrapolation of experiences.

- Bottom up
  - The above implies that we learn best by going from the particular to the general, from special cases to general formalisms. Integration of ideas comes after the specific bits are covered.

- Studying by objectives - Why am I doing this?

- Teacher is <u>not</u> a judge - the teacher is a resource to be used by student.

- Boredom is caused by a sense of new ideas being useless:
  - usually over-stimulation without a chance to integrate, therefore new material is useless, or
  - ideas really are not relevant.

4 Effective Use of Lecture and Study Time

Here is perhaps the most important advice I can give you. Most, I have found, do not follow it but those that do reap the rewards. You have been warned.

Approach the course as follows:

- Pre-read material (books/handouts) before going to class.
- Use the class to ask questions, review, check that you understand material.
- After-class read, clean-up notes.
  - Use this to reinforce ideas. A good study technique is to practice recall; this aids learning and memory.
- Quizzes provide feedback and are a check of understanding. Review for quizzes.
- Do the assignments - use them to interpret material.
- Final exam-review.

Thus, you will have covered the material six times before the exam. How can you fail?

The student <u>must</u> keep up as we go along. It is too hard to catch up later. By pre-reading the lecture notes, the class lecture becomes a review of material that you have understood and a time to discuss material that you don't understand. By pre-reading, you have created a wave that will push you along. Ride the wave! Integration takes time and, if you don't keep up, you won't have the first five ways of effective use of time.

Do not look upon the structure of the institution as the enemy. It is there for a reason. Although one must still get the marks, it helps to understand why the marks are important - they are indicators, often the only indicators that decision makers have. But do not neglect other important aspects that make a good professional engineer such as ethics, intent, insight, etc. Keep your eye on the longer term. Develop good habits and never let a principle pass you by.

Success is habit forming!

5 Tailoring the Method to the Student

Karl Jung subdivided people into their way of thinking:

TYPE	LEARNS BY
Philosopher	Abstracting
Doer	Doing-worked examples
Feeler	Handling hardware
Sensor	Instinct

No one is completely one type. Rather, we are a mixture of types, a blend. Often the blend changes depending on the situation at hand. It is important to note that there is no right or wrong answer. But you should be aware of what type you are. Then you adjust your learning habits and approaches to suit yourself. Spend a few moments to consider this and on the form assign a percentage to each type to indicate the blend you think you are.

TYPE	LEARNS BY	PERCENT
Philosopher	Abstracting	
Doer	Doing Worked examples	
Feeler	Handling Hardware	
Sensor	Instinct	
Total		l00%

There is so much more to be said on this subject. Maybe, someday... Until then, the interested reader might want to check out [KEI84].

Apparently, the left side of you brain specializes in the concrete and logical and is thus responsible for language, procedures, and so on. It is your rational side. The right side, by way of contrast, is better at imaging, abstract ideas, music, etc. It is the artistic you. Engineers are usually labeled as being heavy on the rational side, i.e., left brained. But, while it is true that engineers need to be rational, need to be able to 'turn the crank', need to generally 'color inside the lines', that only accounts for the Analysis portion of the profession. Engineering, indeed, problem solving in general, is more of a right brain activity - it is an act of Synthesis.

The left brain is the engine that is guided by the path set down by the right brained guiding light. And as we shall see in the next section, right-brain activity is essential for problem solving.

6 Problem Solving Strategies

An engineer is a problem solver. The student engineer will solve countless practice problems, yet may not end up with a grasp of how, in some higher level sense, he or she does the actual solving. We get caught up in the technical details and neglect to reflect on the solving process itself. Students mull it over, look for similarities to problems solved before, ... whatever but far too often, students find themselves either stuck at the beginning because they can't see the path forward or racing towards the end as soon as they see <u>any</u> path forward. So let's take a moment to reflect on the process of problem solving. Perhaps we can find some general strategies that will make your problem solving be more effective. This is my personal take on the subject. The reader would be well advised to ponder [WOO94].

6.1 PACE yourself

The solution strategy can be conveniently divided up into 4 main parts:

- <u>P</u>ose the problem
- <u>A</u>nalyse the problem
- <u>C</u>alculate the solution
- <u>E</u>valuate the solution

In short PACE yourself.

6.2 What's the Problem

It seems trite to say that you should be sure of the problem before trying to find the solution but it is surprising how often people in general, and student engineers in particular, jump into solution mode without reflecting on what is needed. Some say that 75% of the solution is in asking the right question.

So, mull over the question being asked for a few minutes and resist trying to answer it.
- Write down what is to be found (the goal).
- Write down what you know (the facts).
- Write down relevant relationships.
- Write down the assumptions.
- Organize or group the information to reduce clutter.
- Make sure you understand the context of the problem.
- Eyeball the situation. Can you make a rough estimate of the kind of answer you will get?

6.3 How to Analyse

There are 2 general ways to proceed. We could start with the data and relationships that we know and calculate forward to find the required goal. For trivial problems, that is fine. For complex problems, however, there are many possible things that can be derived from a data set and, thus, this forward chaining (or data driven) scheme is inefficient. What we really need to do is to work backwards - start with the goal and draw an influence diagram (or data flow diagram or dependency diagram) as per figure 6.1, i.e., establish what information is needed to calculate the goal. Keep working backwards until all the branches are decomposed into nodes which are know (i.e., the problem is expressed in terms of the given data.

Don't skip this phase. It is important.

Does the scheme jive with the rough estimate of the solution that you made above? Can you refine your rough estimate, i.e., your expected results? Try and bound the answer, at least mentally.

6.4 Turn the Crank

This is the easy part. From your analysis, you know what has to be done and how to do it. So just do it. Keep an eye out for odd results as you go along. They are indicators that all is not well.

6.5 Does the Solution make Sense?

So you got an answer. Don't stop now. Reflect on the whole problem and your solution. Does it make sense? Does it all hang together? Do a check on the units. How does the solution compare with your earlier expectations? Are your assumptions still valid?

6.6 Stuck?

Hey, it happens. Using the above process, you'll find that you won't get stuck, paralyzed at the beginning, nearly as often as you used to - for 2 reasons. One, you now have a way forward even though you don't see the full solution yet - onward through the fog, as we say on the East Coast! Two, the simple process of moving forward in a rational manner, decomposing the problem as you go, makes it much more likely that you will uncover the solution. Problem solving is not a state of mind, or an end point or the result of raw intuition or genius... it is a process.

But if you are still stuck, check through the following to see if you can find clues to why you are getting hung up:
- Perhaps you can't see the forest for the trees - you're lost in a sea of numbers. That is an indication that you need more practice in solving smaller, more directed problems. Play around with the fundamental definitions, relationships, governing equations, etc., to make sure you understand terms, properties, units, at the like. You need to be more fluent in these fundamentals before you can tackle the bigger problems much like you can't run before you can walk, speak sentences before you can speak words, play music without learning riffs, etc. The fundamentals

need to be second nature before you can use them as part of your toolset.
- Perhaps you just goofed. Check through your P, A, and C to see if you dropped a digit or something.
- Play around with the problem. Time for some horizontal thinking; step out of the box, and all that. If you can't solve this problem, maybe you can turn it into a problem that you can solve.
- Look at solutions to similar problems. Why do they work? Are there clues there that might apply to the problem at hand?
- Try drawing a Concept Map of the concepts relevant to the problem as per figure 6.2. This might help in uncovering relationships that you might have otherwise missed.
- Talk to someone. Describe the problem and your solution to them. It is surprising how often you see your own mistake when you do this.
- Collaborate with someone. No, this is not the same as copying.

... onward through the fog...

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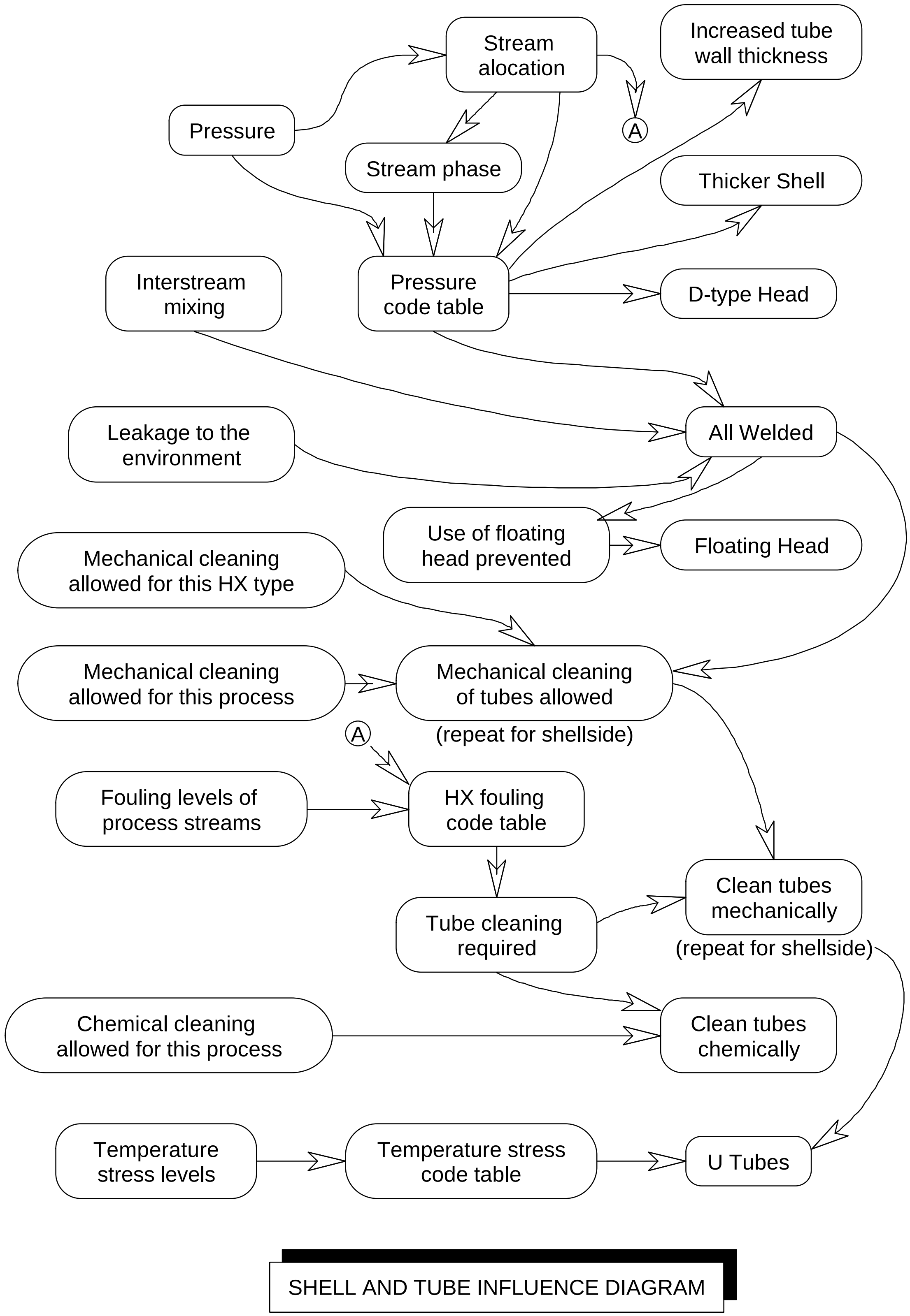

Figure 6.1 Example influence diagram

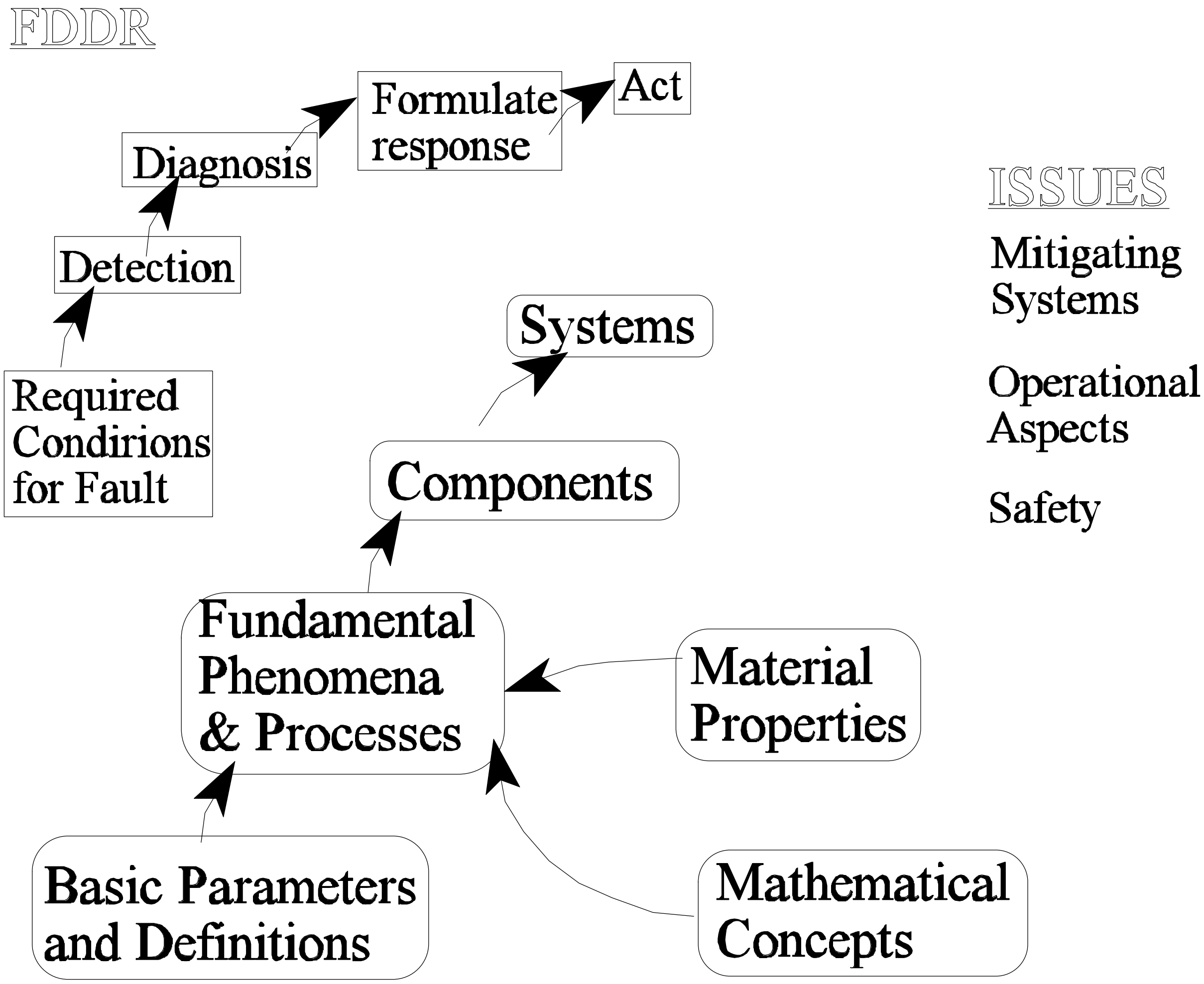

Figure 6.2 Example of a Concept Map

APPENDIX 1 Behavioural Taxonomy

Handout Master 12.5
Objectives in the Cognitive Domain

Operationalizing the Taxonomy of Objectives in the Cognitive Domain

Taxonomic Categories and Subcategories	Verbs to Use in Objectives	Examples of Appropriate Content in Objectives
1.00 Knowledge 1.1 Knowledge of specifics 1.2 Knowledge of ways and means of dealing with specifics 1.3 Knowledge of universals and abstractions	Define Distinguish Acquire Identify Recall Recognize	Vocabulary words Definitions Facts Examples Causes Relationships Principles Theories
2.00 Comprehension 2.1 Translation 2.2 Interpretation 2.3 Extrapolation	Translate Give in one's own words Illustrate Change Restate Explain Demonstrate Estimate Conclude	Meanings Samples Conclusions Consequences Implications Effects Different Views Definitions Theories Methods
3.00 Application	Apply Generalize Relate Choose Develop Organize Use Restructure	Principles Laws Conclusions Methods Theories Abstractions Generalizations Procedures
4.00 Analysis 4.1 Analysis of elements 4.2 Analysis of relationships 4.3 Analysis of organizational principles	Categorize Distinguish Identify Recognize Deduce Analyze Compare	Statements Hypotheses Assumptions Arguments Themes Patterns Biases
5.00 Synthesis 5.1 Production of a unique idea 5.2 Production of a plan 5.3 Derivation of a set of abstract relations	Document Write Tell Produce Originate Modify Plan Develop Formulate	Positions Products Designs Plans Objectives Solutions Concepts Hypotheses Discoveries
6.00 Evaluation 6.1 Judgments in terms of internal evidence 6.2 Judgments in terms of external criteria	Justify Judge Argue Assess Decide Appraise	Opinions Accuracies Consistencies Precisions Courses of action Standards

Adapted from N. S. Metfessel, W. Michael, and D. Kirsner. Instrumentation of Bloom's and Krathwohl's taxonomies for writing educational objectives. **Psychology in the Schools**, 1969, 6, 227–231.

AFFECTIVE DOMAIN OF LEARNING

Five levels of the affective domain:

1. Receiving - Willing to give attention to an event or activity. *Examples:* Listen to, be aware of, perceive, be alert to, be sensitive to, show tolerance of.
2. Responding - Willing, to react to an event through some form of participation. *Examples:* Reply, answer, follow along, approve, obey, find pleasure in.
3. Valuing - Willing, to accept or reject an event through the expression of a positive or negative attitude. *Examples:* Accept, attain, assume, support, participate, continue, grow in, be devoted to.
4. Organizing - When encountering - situations to which more than one value applies, willingly organize the values, determine relationships among values. and accept some values as dominant over others (by the importance to the individual learner). *Examples:* organize. select, judge, decide. identify with, develop a plan for, weigh alternatives.
5. Characterizing by a value complex -
   Learner consistently acts in accordance with accepted values and incorporates this behavior as a part of his or her personality. *Examples:* Believes, practices, continues to, carries out, becomes part of his or her code of behavior.

Source: Krathwohl, D.R. et. al. (1969). A Taxonomy of Educational Objectives. Handbook II. New York: Longman.

C. Taxonomy for the Psychomotor Domain

The categories in this taxonomy are presented in order, from basic (1.) to most complex (7.).

Categories	*Examples of Verbs to Use When Developing Learning or Performance Objectives*
1. Perception — using the senses to obtain cues to guide motor activities	— detect, differentiate, distinguish, identify, listen, observe, smell, isolate, taste, feel, touch
2. Set — being ready (mentally, physically, emotionally) to take a particular type of action	— proceed, react, respond, volunteer, show readiness
3. Guided Response — learning motor skills through imitation and trial and error	— repair, construct, dismantle, keyboard, assemble, dissect, throw, measure, sketch, display, type, print
4. Mechanism — performing motor skills consistently with some confidence and proficiency	— (same list as for "Guided Response" but at a higher level of proficiency, consistency and confidence)
5. Complex Overt Response — performing accurately, automatically, efficiently and without hesitation, motor skills which involve increasingly complex movement patterns	— (same list as for "Mechanism" but at an even higher level of proficiency, consistency and confidence)
6. Adaptation — modifying particular motor skills or movement patterns to meet a new or unexpected situation	— adapt, modify, change, alter, rearrange, revise, vary
7. Origination — creating a new skill or movement pattern to meet a new or unexpected situation	— originate, create, devise, compose, construct, design, arrange, combine

Source: Making the Grade. (1987). Scarborough: Prentice Hall. (pp. 32).

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