DOCUMENT RESUME

ED 384 310 HE 028 423

AUTHOR	McNeill, Barry; Bellamy, Lynn
TITLE	A Guide to Self Evaluation and Documentation of Educational States.
PUB DATE	95
NOTE	46p.; For related documents, see HE 028 424-428.
PUB TYPE	Guides - Classroom Use - Instructional Materials (For Learner) (051)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Cognitive Processes; *Competency Based Education; Definitions; Evaluation Methods; Higher Education; *Item Sampling; *Portfolio Assessment; Scientific and Technical Information; *Self Evaluation (Individuals); Student Evaluation; Student Journals
IDENTIFIERS	*Competency Matrix

ABSTRACT

This guide is designed to help college students understand educational states, portfolio assessment, competency matrices, and self-evaluation as it relates to the presentation of technical materials in the engineering sciences. Part 1 discusses definitions of education and learning, the concept of lifelong learning, and educational states (cognitive, affective, and psychomotor domains). Part 2 addresses the presentation of technical work, focusing on techniques to present homework, graphical material, analytical models, computer models, and spreadsheets. Part 3 discusses the creation of portfolios and matrices, focusing on portfolio structure, filling the portfolio, creating an index, and appropriate matrix columns. Part 4 explores the self-evaluation process, focusing on various documentation instruments that are used for recording and storing assignments, including portfolio notebooks, competency matrices, work logs, run charts, and reflection logs. It also outlines a self-evaluation process for use with portfolios and competency matrices. Two appendixes present activities at various cognitive levels of learning and affective degrees of internalization, as well as a sample competency matrix, a reflection log template, a work log template, and a sample run chart. (MDM)

Mini

A Guide
to
Self Evaluation and Documentation of Educational States

by
Barry McNeill
Mechanical Engineering Department
With Deviations
by
Lynn Bellamy
Chemical Engineering Department
Arizona State University

Table of Contents

Preface

In this class you will be creating a Portfolio of your work and developing a special index to this work. A *Portfolio* is just a fancy name for an organized collection of all the work you will do during the semester. While some of you may already have methods for organizing your work, in this class you will be asked to organized the work in a rather special manner, one that makes the assessment of your performance easier to do. At the end of the semester your Portfolio will contain the evidence of what you did and, by implication, evidence of what you have learned. Theoretically, it should be possible at the end of the semester for anyone who knows the course expectations to look through your collection of work and decide how well you did in meeting those course expectations (i.e., assess your performance). The grade you receive in the course is, in some way, a function of this type of assessment.

The assessment job can be made easier if it is easy to find the specific work that is related to a specific course expectation. For example, if during the course it is expected that you will learn how to extract derivatives of trigonometric functions, it would be nice to know where in your Portfolio there is work related to extracting trigonometric derivatives. This connection from expectations to specific pieces of work can be done in several ways but in this class the connection will be done using a special index known as a Competency Matrix. You will build this index continuously during the semester as you do your course work and put it into your Portfolio.

You may be asking yourself *Why all the fuss with Portfolios and Matrices? What was wrong with the old way of just submitting the work and getting a grade?* The answer is that using Portfolios and a Competency Matrix greatly enhances the assessment process. For one thing it tends to make assessment more uniform (i.e., more fair). But more than that, it also allows more than just the course instructor to do the assessing. In particular it makes it possible for you to do the assessment. Exactly how much self assessment you actually get to do will be a function of the course and course faculty but you can expect to do some and in some cases you may do the majority of assessment.

Acknowledgments

The material presented in the Guide is a compilation of the thoughts and experiences of Drs. Jim Bailey, Lynn Bellamy, Don Evans, Mark Henderson, Darwyn Linder, Barry McNeill, Jack Pfster, and Greg Raupp as they attempted to utilize the idea of a competency matrix in the evaluation of student performance in their classes during the last several years.

LB & BWMcN

Part I -- Introduction

Have you ever wondered:

1. what an education is, or
2. what it means when you *learn* something, or
3. if you only learn in school, or
4. whether your education stops when you leave school?

These are not easy questions to answer and some people spend their whole lives attempting to formulate answers, but hard as it is, you do need to think about answers to these questions. Before reading on you might like to jot down some reflections on these questions.

Education and Learning

So what are some answers to these questions. Starting with the most difficult first, *The Random House College Dictionary* defines *education* as:

> the act or process of imparting or acquiring general knowledge and of developing the powers of reasoning and judgment

This shows *education* to be an active, dynamic thing (*imparting*, *acquiring*, *developing*). *Education* causes a change in your general knowledge and/or in your ability to reason and use judgment.

Following this definition it seems reasonable to expect *learning* to be associated with the actual *acquiring* or *developing* part in this definition. When you *learn* a history lesson you are obtaining knowledge about the activities going on during some period of time. When you *learn* to drive a car you gather knowledge about the car, the rules of the road and develop a sense of when it is and is not safe to pass, a reasoning/judgment activity. So *learning* is the method or way that you acquire and develop knowledge and wisdom. There is no one, correct way to learn something and different people learn things in different ways.

The third question, concerning whether you can only learn something in school, seems patently false. School in only one of the many places that you learn. You certainly learned how to walk and talk outside of school. You learned to drive a car outside of school. In fact much of your learning takes place outside of school. Education is not limited to schools or universities.

Life Long Learning

Now to the last and probably most important of the four questions, does the end of schooling mean the end of education? The answer is a resounding NO. In fact your education never stops. If you want to continue to be a productive useful person you continue to learn throughout your life. As your interests and needs mature and change you need to acquire and develop new information and judgmental skills. A university degree only starts you down this long process but never completes it.

So if the University does not complete this education process, what does it do? Universities help you move to adulthood with its myriad of responsibilities. At the undergraduate level, Universities are learning environments that help you *learn how to learn* so you, as an adult, can take full responsibility for your own education. Universities help you to learn[1] at a time when you may not be mature enough or have enough knowledge to know what you need to learn. But at the same time Universities must eventually wean you from this dependency of authority figures defining what you need to learn because you eventually leave the University and unless you know how to learn, your education stops prematurely at graduation.

---

[1] e.g., structured curriculum

Learners Capable of Autonomous Learning Will Characteristically:

Be Methodical / Disciplined

- Be able to focus on an area of interest
- Develop individual plans for achieving goals
- Establish personal priorities
- Pay close attention to details of an ongoing project

Be Reflective / Self-Aware

- Decide what knowledge and skills to learn
- Have a self-concept as an effective learner
- Know his or her strengths and weaknesses
- Understand his or her own values, interests, abilities, and knowledge

Demonstrate Curiosity / Openness / Motivation

- Be curious, with a continual need to learn
- Be "cognitively open" with regard to phenomena
- Confront questions and problems willingly

Be Flexible

- Be able to learn in many situations - from conversations, through reading, and by observation
- Be able to learn from listening, taking notes, reading, or memorizing
- Be able to accept or reject material
- Be able to achieve or abandon goals

Be Persistent / Responsible

- Be capable of intellectual concentration
- Stick to plans, modifying as necessary
- Have a tolerance for frustration
- Detect and cope with personal and situational blocks to learning

Have Developed Information Seeking and Retrieval Skills

- Intelligently select and use most relevant sources of information
- Identify, and know how to use, resources appropriate to different kinds of learning objectives
- Be able to establish feedback mechanisms for day-to-day performance

Have Knowledge About and Skill in "Learning Processes"

- Be capable of reporting what he or she has learned in a variety of ways
- Be able to decode a message - textual, auditory, or visual
- Have developed skills in taking notes, remembering, and relating

Develop and Use criteria for Evaluating

- Be able to select what is of value from the mass of information available
- Participate in diagnosing, prescribing, and evaluating his or her own progress

Figure 1 Profile of the Autonomous Learner[2]

[2]Excerpted from : Philip A. Candy, Self-Direction for Lifelong Learning. San Francisco, Jossey-Bass, 1991, pp 459 - 466

Introduction

The primary goal of a University is to graduate Life Long Learners, people who can learn by themselves, people who can learn and want to learn autonomously. Philip Candy has developed a set a characteristics of an Autonomous Learner that are shown in Figure 1. Read through Figure 1 and see how many of these traits apply. If the answer is *not many* that is OK, much of what you will do in this class is aimed at starting the change in your attitude toward learning, i.e., moving you closer to the profile of the autonomous learner.

Educational States

By definition, education is a process, which means that things change. So what is changing and how do you measure this changing quantity? What is changing are your behaviors, attitudes, knowledge, skills, and reasoning powers. This collection of things is covered under the umbrella concept of an Educational State. This makes the definition of education become:

> Education is the process that changes a person's educational state

Traditionally the evaluation of the status of your educational state has been done by course instructors who assign a grade to indicate your **state**. While it may be relatively easy to let instructors do this evaluation of your work (i.e., you do the assigned work, submit the work and wait to see what the instructor reports), as pointed out above, in the long term you will need to be the person doing the evaluation. You cannot continually rely on someone else to tell you how you are doing; you must learn how to evaluate your own educational state so you can make the required improvements.

How can educational states be defined or characterized? While there are many ways to do this, one possible way is to characterize your educational state by the activities and actions of you and your teacher (i.e., your behavior). Reflect back over your time in school; you should be able to recognize the gross changes that have taken place in your activities. Early on you learned facts and worked **simple**, single concept problems; towards the end you worked problems that combined many different concepts and skills.

In the early 1950's a group of educational psychologists addressed the problem of defining educational states. To quote from the Foreword to their first efforts:

> It (this work) is intended to provide for classification of the goals of our educational system. It is expected to be of general help to all teachers, administrators, professional specialists, and research workers who deal with curricular and evaluation problems. It is especially intended to help them discuss these problems with greater precision.[3].

These psychologists divided the problem into three behavioral domains: the cognitive, dealing with the *recall or recognition of knowledge and the development of intellectual abilities and skills*; the affective, dealing with *interests, attitudes, appreciations, values, and emotional sets or biases and* the psychomotor, dealing with the *manipulative or motor-skill area*. What these psychologists attempted to do was define a finite set of recognizably distinct behaviors and then to sequence these behaviors in the order they occur when someone is learning (i.e., they were striving to define a taxonomy of cognitive, affective and psychomotor behaviors associated with learning).

Cognitive Domain

A taxonomy[3] (a handbook), that dealt with the cognitive domain, was published in the mid 50's. After much discussion and testing of ideas with a wide range of colleagues, Bloom et al proposed a cognitive taxonomy containing six major categories. In order of increasing complexity (and order of learning) they were: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Each of these categories was characterized by a different set of abilities (behaviors) exhibited by a person operating in the category. This taxonomy turned out to be widely accepted and is the basis for many curriculum development efforts.

---

[3] *Taxonomy of Educational Objectives Book I Cognitive Domain*, Bloom et al, Longman, 1956.

Introduction

In the late 80's and early 90's David Langford, in attempting to implement an important aspect of the quality culture (empowerment) into the classroom, recognized that the cognitive taxonomy could be used by the students as well as the teachers to determine where they were relative to these various objectives. Thus Langford proposed having the students use these educational objectives to do self evaluation. Langford renamed the objectives Levels of Learning, changed the name of Comprehension to Know - How, and developed summaries of the types of activities a student and teacher would do when they, the students, were operating at these various Levels of Learning[4].

A modification to Langford's material on typical activities can be found in the first six pages of Appendix A. This material consists of answers to a set of seven standard questions. The answers to the questions change as the Level of Learning changes. For example, the answer to the question of *How do I know I have reached this level?* is answered as, *I recall information*, at the Knowledge Level but is answered as, *I have the ability to put together parts and elements into a unified organization or whole that requires original, creative thinking*, at the Synthesis Level. Read these answers over carefully, paying especially close attention to the first two and last three questions for each of the levels.

Affective Domain

As the psychologists had pointed out in the 50's, there is more to defining an educational state than is covered by cognitive behaviors (Levels of Learning) along. There are the affective behaviors that must also be considered. These affective behaviors cover a wide variety of things ranging from your willingness to receive and try new material or your interest in what is being learned to your sense of value in what is being learned or how the material is being learned. Aside from these sorts of issues, the affective domain also involves the somewhat related issue of Character (honesty, integrity, truthfulness, etc.). Myron Tribus, in several of his recent essays[5], stated that Character is one of the major categories of things that should be cultivated in a school or university.

What are the affective stages you pass through during the learning process? In the mid 60's a sub set of the group of educational psychologists who had produced the cognitive taxonomy published a second taxonomy[6], one that dealt with the affective domain. Compared to cognitive behavior, affective behavior is a much softer (i.e., harder to define) type of behavior with the result that the development of the affective taxonomy turned out to be a rather difficult job. It was hard to define exact categories of behavior that had definable boundaries; the categories seemed fuzzy and blurred rather than crisp and focused, as was more the case for the cognitive categories. In the end Krathwohl et al defined five major categories, that in order of increasing complexity (called Degrees of Internalization) were: Receiving, Responding, Valuing, Organization, and Characterization by a Value or Value Complex. Each of these categories was characterized by the set of behaviors exhibited by a person operating in the category. Because the affective domain is a rather fuzzy domain, the affective taxonomy never enjoyed the wide spread acceptance as that given to the cognitive taxonomy.

The last pages of the material in Appendix A address the affective domain. You will find general material for the first three Degrees of Internalization. Only the first three Degrees of Internalization are discussed because the top two degrees are ones that are never attempted nor should be attempted in a university classroom setting. These top two degrees involve the integration of the value of learning and material learned into your personal value structure, a structure that encompasses much more than educational values and thus movement to these higher degrees of affective behavior must take place outside the classroom, in the broader context of your life.

---

[4] *Total Quality Learning Handbook*, Langford Quality Education, 1992

[5] *Quality Management in Education*, and *Total Quality Management in Schools of Business and of Engineering*, Myron Tribus, Exergy, Inc., Hayward, CA

[6] *Taxonomy of Educational Objectives Book 2 Affective Domain*, David Krathwohl et al, Longman, 1964.

Psychomotor Domain

The last piece of the educational state is defined by your psychomotor skills and abilities. As of this writing there has been no definitive taxonomy of these behaviors and you will not be expected to evaluate this part of your educational state.

This Guide

The remainder of the material in this guide is organized into three parts and a set of appendices. Part II discuss expectations concerning how your work is presented. Part III takes you through the mechanics of creating and using the portfolio with little or no justification for the process. Part IV is a more detailed discussion of the assessment process and attempts to explain the steps in more depth. If you have never used a Portfolio or Competency Matrix you will want to read the first part of Part II and all of Part III, doing the work suggested. Once you have a sense of what is going on you will want to read Part IV to get a better understanding of the process so you can improve the process.

Part II -- Presentation of Technical Work

Before discussing how to organize and assess your work it is necessary to generate and present some work. It is not as if you have had no experience in doing this[5]; but I am sure you have all had situations where the evaluation of your submitted work was lower than expected, at least partially because the work, while technically correct, was not presented well (in the eyes of the teacher). Your ability and that of others to assess your work depends, to a large extent, on how you choose to present (i.e., document) your work. A large part of the evaluation process is directly related to the quality of the presentation, which is related to the evaluator's expectations. It is necessary that you realize what is expected so you can supply it.

This portion of the guide presents some general traits of quality presentations and then addresses some specific presentation issues.

General Presentation Traits

While specific expectations for presentations vary depending on what sort of task you are documenting or who is reading (evaluating) the material, there are some general, philosophical guidelines, that can help you achieve a good presentation (documentation) of your work. On first look, these traits may seem to require extra work and be solely associated with a desire to make the work understandable to someone other than yourself. Upon reflection, however, you should realize that this work is not really extra. When you do the *extra* work required to make the work understandable (i.e., presentable) to other people, you actually achieve a better understanding of what you have done (are doing) and with this understanding comes the knowledge of how to do the work even better than you first envisioned. It is hard to consider anything that allows you to do your work better to be considered as *extra* work.

When presenting your technical work, you should strive to:

1. explain what is going on
   You should attempt to let the reader know, at all times, what is going on. This means explaining what is being attempted, why it is being attempted, and what method is going to be used. This also means that at the conclusion of a task you explain the consequences or meaning of what you have just done.
2. make explanations clear
   While trait #1 addressed the need to explain what is going on; this trait addresses the issue of making this explanation clear (i.e., reducing the variation in interpretation). Clarity is often enhanced by using sketches, plots, figures, etc., some type of graphical presentation to augment the text. Clarity is also improved when terms and variables are defined.
3. make it readable
   Anything you can do to make the work easier to read will help improve the presentation. Explaining clearly what is going on improves readability. Other ways to improve readability are doing neat work, having clean sketches, having the material bound so that it does not fall apart and yet is easy to access, numbering the pages, etc.
4. make it clear whose work it is
   It should always be clear who did the work and when the work was done. This is usually done by dating and initialing each sheet of work done.

You should strive to incorporate these traits into all your presentation efforts; leaving out even one of the traits reduces your chance of having an adequate presentation.

---

[5]During high school and college you have done homework, generated reports, etc. that were submitted to a teacher for evaluation (grading).

Presenttion Expectations for Some Types of Technical Work

There are clearly many many different types of work to be documented and no attempt will be made to address all types of work. Rather, the expectations for a few types of work, work that you will encounter in your engineering classes, will be discussed. Homework, plots, and computer models will be discussed. If this is your first time through the guide you may want to skip the material on models and come back to it at a later time.

homework

You have homework in every engineering class that you take. While you will find that the format for homework (e.g., the size of the margins, the order in which material is presented, the way answers are presented, etc.) will vary from class to class, you will also find that the expectations for what is presented will not vary much from class to class.

When the general traits of good presentation are applied to your homework, the following set of expectations emerge.

1. State The Problem
   Write down the problem statement as it is given in the book or assignment sheet. This sets the context for the problem and the work (addresses general trait #1).
2. Draw An Appropriate Diagram Or Sketch
   The diagram should show the information given in the problem and show what is being solved for. Thus if the problem were to determine how much force it would take to lift a safe using a lever and fulcrum (pivot), then your diagram would show the lever, the fulcrum, the safe and you, pushing down on the lever (addresses general trait #2).
3. Describe Your Process
   Describe in a few sentences what process, methods, approaches you used in working the problem. You should include any assumptions you have made. For example in the safe/lever problem, you might say you are going to use a force balance (or equilibrium). This should be more detailed than just stating a general name (e.g., force balance); you should describe a few of the key steps in the named process (addresses general trait #2).
4. Show Work
   For the process stated in 3 work the problem, showing all appropriate work.
5. Discuss The Answer
   You must contemplate or reflect on your answer and present some comments about the answer. What does the answer mean? Is the answer bigger (smaller) than expected? Is the answer reasonable? What might be done next? These are only a few of the possible types of questions you could address when you are writing your discussion of the answer (addresses general trait #1).

   If your work has created a plot or a table of figures then you must discuss each of the plots or tables. What is the trend? Can you extrapolate?

When you prepare your homework for this or any other engineering class, you are expected to adhere to these five points. Failure to follow anyone of these points means that you are not meeting the expectations of most course faculty (and as you will see later, not meeting your own presentation expectations).

graphical material (including plots)

Much information is contained in pictures and hence your work will often contain significant amounts of graphic information (general trait #2). This graphic material is generally either pictures of an artifact or plots showing the relationships among some variables. Because pictures concisely contain so much information (i.e., pictures capture the essence of the material) graphic material is frequently copied and distributed, often without the accompanying text. Since this practice is so ubiquitous, it is critical, when preparing graphic material, that you:

1. add enough annotation to the material that the picture makes sense standing alone, and
2. make the graphical material so it can be reproduced.

The first of these items means you put titles and labels on all your graphic material while the second item means that you do not put your drawings on green grid graph paper using a number 3 pencil.

Aside from these two general items, there are some standard expectations concerning the presentation of plots that you will want to be aware of and follow. These plot expectations are:

1. Both axes of a plot must be labeled, including units when appropriate. The use of only a variable (e.g., V) as the label is discouraged because of the different interpretations (e.g., is V volume, velocity, etc.). Using only variables as labels goes against general trait #2.
2. The divisions for each axis must be marked. It must be clear what value the plot *origin* (intersection point of axes) has.
3. The plot must have a descriptive title including a Plot or Figure number. A title like P vs T is not considered to be descriptive and must be replaced with something like *Container Pressure as a Function of the Internal Tank Temperature.*
4. The dependent variable is always plotted on the vertical (*y*) axis. This expectation has ramifications concerning plot titles (see item 3). In a title it is expected that the dependent variable (the one calculated) will be mentioned first and the independent variable (the one you changed) will be mentioned second. For example, if the title is *Production Flow rate vs Compressor Discharge Pressure*, you know that the discharge pressure (mentioned second) is the independent variable and is shown along the horizontal axis while the flow rate (mentioned first) is the dependent variable, plotted along the vertical axis.
5. If you are displaying a number of related curves on the same plot you need to have a concise legend defining the various curves.
6. Data-points used in generating the plot are generally shown.
7. Smooth curves are generally drawn through or near the data points to show the trend.

The above expectations are true for any plot, whether it is hand or computer drawn, whether found in your homework or a report. You may find that computer drawn plots do not meet some of these annotation standards. In such cases it is entirely permissible to add the annotation after the plot has been generated. You can add this annotation by hand, with a typewriter or transfers.

analytical models [6]

Analytical models turn out to play a big role in engineering and it is very important that you realize what is expected when presenting your work. The material that follows is divided into three major areas. First is the issue of how to present the work related to the development of the model. Second is the issue of what is expected concerning the model itself. Third is the issue of presenting the work related to the use of the model.

analytical model development

What is expected for analytical model development follows directly from the general traits. Analytical model development concerns all aspects of assembling the set of equations that are used to predict performance. After reading the model development material it is expected that the reader will believe that the work is complete and correct. It is expected that all model development work will:

1. define the system being modeled (general trait #1, & 2),

---

[6]This material makes sense only after you have some idea of what analytical models are. If you do not have this knowledge then skip this section and come back later after you start building and using analytical models.

2. define the model limitations (general trait # 1),
3. define the model variables (general trait #2),
4. establish the appropriateness of the modeling method (general trait #1), and
5. establish the correctness of the model's results (general trait #1).

The first three items are relative straight forward and most likely reflect the sorts of things you have been doing. The fourth item is one that may not currently be part of your presentations. For homework type problems the appropriateness of the modeling method is often assumed (implicit and not stated), why else would the assignment have been given. Even so, it is important to address this issue when presenting model development. There are several ways to establish the appropriateness of your model You can cite experts. You can also build up the model from basic principles of science and mathematics. Appropriateness also requires addressing the issue of whether you have the necessary resources (time, money, computer power, expertise, etc.) to implement the model, i.e., applying Occam's razor.

The last item is again an issue you may or may not have explicitly addressed up to now. It is expected that you will present work to show that the model is actually working correctly (i.e., that there are no errors in the model). This is not a trivial task and there are a variety of things you can do, each with a different degree of credibility. Probably the best way to show model correctness is to run your model with a test case that has known answers (e.g., run a homework problem from a text book). If this is not possible the next best method would be to show that the model generates results (designs) similar to existing designs (e.g., the models predict rocket nozzle sizes of the same size as those found in industry). Next in line might be to show that the model *behaves* correctly (i.e., when inputs are changed the outputs change in the predicted fashion). Some confidence in model correctness can be obtained by showing that the model generates correct order of magnitude answers. Probably the least likely to convince but which does show some evidence of model correctness is to show that the model reproduces the results of some earlier, paper and pencil work.

computer models

The above discussion applies to any model that is developed, independent of the method or tools used in running the model. When developing computer models there are some additional documentation expectations that help assure that the computer model is understandable and correct.

high level languages

If the model is developed using a high level language such as C, the computer code must include comments and a variable dictionary. A listing of the program must be included. The listing should be easy to read (i.e., not bound into the documentation in such a manner as to make reading impossible). Any model that exceeds several hundred lines of code should be broken up into a set of smaller subroutines or procedures with an accompanying flowchart to explain the general program logic and control.

formula solvers

If the model is developed using a formula solving program such as TK then the documentation must include a completed Variable Sheet[7] including the Units and Comments Columns. The Variable Sheet must show a consistent set of values for **all** variables. You must also supply a copy of the Rule (Equation) Sheet. The Rule Sheet should contain some general comments to tie major sets of equations together. There must be enough annotation on the Rule Sheet to explain the basis for the various equations or sets of related equations. If the model uses any special user defined functions these should also be included in the material submitted. User functions should be documented in the same fashion as the equations on the Rule Sheet.

---

[7]Equation solving programs have a variety of input and output screens which they call sheets. Some of these programs can solve multiple cases by running in what is called *List Solving*.

spreadsheets

Documenting a model when a spreadsheet is used is a bit more difficult than when high level languages or formula solvers are used because spreadsheet equations use cell addresses rather than variable names. About the best thing you can do when spreadsheets are used is to make sure each column and row of the sheet has a clearly defined title or heading. If the sheet's equations are not *intuitively* obvious then you will probably have to append a report that explains what calculation is being done in each cell.

In developing a spreadsheet model, there are some things to consider that, if done, will generally lead to a quality model. In particular:

1. Start with a plan. Work out on scratch paper what the spreadsheet is going to look like.
2. Keep data entry and calculation areas separate. If the sheet has many inputs you may want to have an entire screen reserved for the inputs.
3. Make the spread sheet appear the same as the scratch paper work.
4. Try to concentrate your data entry. Try to arrange the inputs to sequential rows in a few columns (or sequential columns in a few rows).
5. Do not hardcode "design constants or parameters" into your formulae. Make these constants inputs to the model.
6. Break large calculations down into a set of smaller calculations and put the smaller calculations in adjacent cells on the sheet.
7. Always test your spread sheet (see item 5 under model development).
8. Use cell protection for protection and highlighting.
9. Use column and row labels as well as adding operating instructions to the sheet (i.e., annotate your sheet).
10. Back up your files.

the use of models

Once a model has been developed and shown to be correct you will be using the model to aid you in making decisions or understanding some system. You may use the model one or two times or in some instances you may run the model a very large number of times (i.e., you will run a number of design cases). It is easy to be overwhelmed by the enormity of data that can be generated with a computer model, and the presentation of this work needs careful consideration. The two issues discussed below concern how to display the results of all these runs and how to discuss the results of the runs.

displaying the results

The important results of any case, such as those used to substantiate a conclusion, can be displayed using plots and or tables. Tables are required for any plot shown but there is no need to generate plots for all the tabular data; only the most important relationships need to be plotted. The data from all cases that are run using the same model (i.e., the equations are not changed from run to run; only the input data are changed) should be grouped together in some logical order (chronological, variable changed from case to case, etc.).

It is important that for each case run, the values of all the variables be known. Generally you will have a large set of variables that are not changed for any of the cases and a smaller set of variables that are change from run to run. A listing of the fixed variables along with their fixed value needs to precede the case results. For each case that you run, you will generate a set of lists, probably collected into a table, showing how the other variables changed. For each case, you must annotate the lists (tables) with information explaining what has changed from the previous case (i.e., give the values of the changeable variables). If you use a general table containing numerous variables, only

some of which are of interest for each case, you must mark the variables of interest (using a highlighting marker is acceptable).

discussing the results

When you present the results of your work you need to explicitly discuss the results (i.e., you never just submit a plot or a table without some discussion of the table or plot). This discussion most likely takes the form of a written discussion located in front of the work (the tables or plots). When you develop this discussion you should look at the data and then tell the reader what you want the reader to notice (explicit presentation); do not make the reader figure out (i.e., infer) what is important or interesting about the data (implicit presentation). Explain what decisions you have made or will make based on the data. If the data has any anomalies do not just ignore them; either attempt to explain why they are there or admit that after consideration you cannot really explain the unusual (unexpected) shape. The discussion must refer to the plots and tables by their names or numbers .

Part III -- Portfolios & Matrices Made Easy

Now that you have things to present how should they be organized? Organizing your work is always a good goal. Organized work is work that can be used again. It can be used to review the semester's work; it can be used to remind you how to do something a year later; it can be used to show someone else what you have done. There are many ways to organize the work (e.g., chronologically, by assignment number, alphabetically, etc.), each a good way depending on the reason you have for organizing the work. In this class the goal is to organize the work in a fashion that makes assessment easier to do.

This is a three step process. First, an organizing structure must be defined and implemented, second, the work you do must be placed some place within the created structure, and third, the index to the work must be updated. The first step is the creation of an empty but functional Portfolio; the second step is the filling in of the Portfolio; the third step is the updating of the Competency Matrix. The last two steps are the assessment steps and are the most difficult to do. This part of the guide is meant to make it possible for you to start the assessment process without completely understanding the process. Once you have the hang of what is expected in this part, you will need to move on to Part IV, which focuses on the assessment process itself. Hopefully by the time you are reading Part IV, the mostly mechanical things you have been asked to do in this part will begin to make some sense.

Creating an Empty Portfolio Structure

The following steps take you through the process of setting up a Portfolio for a class. An example, using the Competency Matrix shown in Appendix B, is given.

1. Purchase a three ring binder with hard covers that can take standard three hole punched paper The size binder you need will depend on how much work you will be doing during the semester but unless you are told differently a two inch thick binder should be adequate. You should also purchase a number of tabbed page dividers (see item 3 to determine how many dividers you need).
2. Get the Competency Matrix for the class from your course instructor (see Appendix B for matrix to be used in the example).
3. Label your page dividers as follows and put them into the binder
    1. Mark the tab on your first divider **0-competency matrix**
    2. You now need to create a series of numbered dividers, one for each of the *Learning Outcomes* in your matrix.
        a. Look at your Competency Matrix, you will see the left hand column is labeled as either *Learning Outcomes* or *Competency Category*. If you look in this column on each page of the matrix you will see from one to three (four) different topics listed. Each topic is a learning outcome (competency category) for the course. For the matrix shown in Appendix B there are two learning outcomes: *differentiation* and *team meetings*.
        b. Look through the entire Competency Matrix and count the number of different learning outcomes. If the number is N then get N more page dividers out. For the Appendix B course you would get out two more dividers (i.e., N=2).
        c. Label each of your N divider's tabs with a number and *Learning Outcome*. For the Appendix B course you would end up with two dividers with tabs labeled as **1-differentiation** and **2-team meetings**.
    3. Label the next divider **N+1 class notes** (for example it would be **3-class notes**)
    4. Label the next divider **N+2 work logs** (for example it would be **4-work logs**)
    5. Label the next divider **N+3 run charts** (for example it would be **5-run charts**)

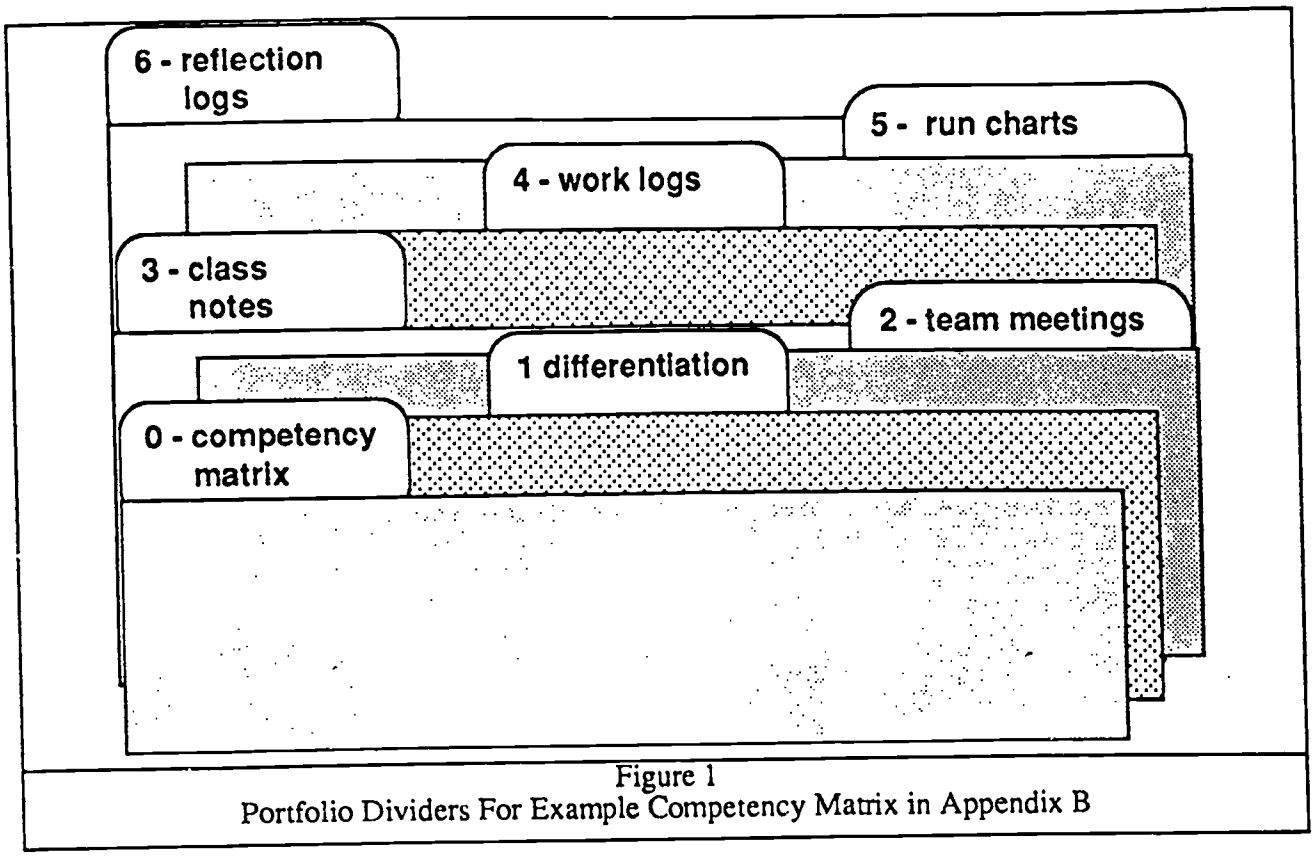

Figure 1
Portfolio Dividers For Example Competency Matrix in Appendix B

6. Label the next divider N+4 **reflection logs** (for example it would be **6-reflection logs**)

4. Punch holes in your competency matrix and insert it behind the first divider.

Your Portfolio is now set up, ready to be used. It has N+5 dividers (counting the divider for the competency matrix), the competency matrix, but no work. The next section explains how to get your work into your Portfolio. Figure 1 shows what the dividers would look like for the sample Portfolio for the class using matrix in Appendix B.

Filling the Portfolio

You now have an empty Portfolio with a need to fill it up with your work. Let's see how this might work for the class using the matrix in Appendix B. Assume you have been given an assignment at the end of a Section that requires you to differentiate five trigonometric functions, three of which required implicit differentiation and that you completed the assignment, presenting your work according to the expectations of the course instructor[8]. The question is: Where does this work go?

This question may be answered in one of two ways. First, you may find that your instructor has explicitly told you what Leaning Outcome this assignment is related to (e.g., *this assignment involves the Learning Outcome of differentiation*), in which case you now know which section of the portfolio (i.e., differentiation) to place the work. On the other hand, if the instructor has not explicitly told you anything then you have to figure this out for yourself. To do this you must find the *Learning Outcome* that covers the work and put the work in that section of the Portfolio . In our example the Competency Matrix shows that there are only two possible *Learning Outcomes*:

[8]This means you have prepared your work according to the expectations for homework discussed in Part II of this guide

differentiation or team *meetings*. There is little question that for this work, the work is covered by *differentiation* and thus the work belongs in Section 1 of the Portfolio.

This example was relatively easy but what do you do when it is not so clear-cut? The Competency Matrix can help you decide if a particular *Learning Outcome* covers the work. In your Competency Matrix the *Learning Outcomes* are further defined as rows within the *Learning Outcome*. In our example, the course learning outcome *differentiation* is meant to include five things (exponential functions, hyperbolic functions, implicit (differentiation), polynomials, and trigonometric functions). For our example, this break down shows even more clearly that the work just completed truly is covered by the first outcome and belongs in Section 1 of the Portfolio.

Before you punch holes in the work and insert it into the Portfolio you need to add some page numbers. If this is the first work done in the section, then number the pages 1.1, 1.2, ..., 1.9 (assuming the assignment was nine pages long). If there is already work in the section find the last page number and start with the next number for this new work. Thus, if the last page number were 1.45, you would number this latest work as 1.46, 1.47 .., 1.54. Notice that the page number includes both the section number (1) as well as the page number (45, etc.). Once the page numbers have been affixed to the work, punch three holes in the work and add it to your Portfolio.

Problems in Determining the Portfolio Section

The process just discussed is reasonably straight forward but questions do come up. Here are a couple of common questions with some suggest solutions.

1. *I cannot find a Learning Outcome that covers the work I have just done*

   You need to look again, more closely, at the Competency Categories (the rows in the matrix) to make sure there are no rows covering the work done. If you cannot find any row that you feel is related to your work, you need to discuss this with the course instructor. You either do not understand what some of the rows actually mean (most likely problem) or you have done work beyond what was expected by the course instructor.

2. *The work I have done seems to fit into more than one section*

   This is not an uncommon situation. You could duplicate the work and put copies of the work in each appropriate section but this is not really needed or desirable. You should select one section and put the work in that section. There is no correct way of selecting the section but you might consider putting the work in the section that has the most matrix rows addressed by the work.

Now you have a Portfolio containing work prepared to meet the presentation expectations of homework but you still have not created the index, the last step and the subject of the next section.

Building the Index

This is the most difficult part of the process. You need to enter, some place on your Competency Matrix, the page numbers of the work you have just placed in the portfolio. The question is where in the Matrix do these page numbers go?

The question is already half answered. To determine where in the Portfolio to put your work you had to decide on a *Learning Outcome* and most likely the rows within the *Outcome* associated with the work. Thus for our example, we know the matrix rows of interest are rows 1.3, and 1.5 (implicit, trigonometric functions). The question now is where along the row (i.e., in which matrix box) do you enter the page numbers?

Again this question may be answered explicitly by the course instructor (e.g., *This work, when done correctly, shows Comprehension for implicit and trigonometic functions*) in which case you would enter page number 1.46 (the starting page number for the new work) into the matrix boxes located at the intersection of rows 1.3, and 1.5 and Comprehension column.

When the instructor does not tell you the matrix location for the work, then you have to determine this for yourself, the start of the self assessment process. To determine the matrix location you have to understand what the nine columns under the Affective and Cognitive titles mean and the distinctions between them. As pointed out in Part I these columns represent increasing levels of understanding (cognitive columns) and interest or attitude (affective columns). Some of the characteristics or traits of work done at each of these levels is given in Appendix A to help you make this decision.

Once you begin to understand these definitions, the question of which box to put the page numbers in can be answered: You put the page numbers in the box under the highest level of understanding or interest justified by the work as presented in the Portfolio[9]. In our example, after reading the discussions in Appendix A, it seems reasonable that the work shows Responding and Comprehension (both of these levels apply to working homework type problems) and you should put page number 1.46 into the boxes at the intersection of rows 1.3, and 1.5 and the Responding and Comprehension columns.

Problems in Determining the Appropriate Matrix Column

This process just discussed takes some practice and you will need guidance from your course instructor. Here are some common questions with some possible solutions.

1. *When I look at my work and at the definitions of the levels and degrees in Appendix A, I see some matching at a particular level but the match does not seem to be complete*

   This will occur all the time. The material in the Appendix is rather broad and covers a number of different ways (activities) that show you are operating at the level of interest. It is not expected that your work will match all aspects of these definitions.

2. *It seems to me that I have matches in several different levels or degrees, which one should I claim?*

   This will occur rather frequently. The levels and degrees are based on taxonomies[10] that means the higher levels and degrees grow out of or upon the lower levels and degrees. You will find that the difference between the upper and lower levels and degrees is more the environment within which you did the work[11] or how you present you work rather than the work itself. When two levels are possible you should always choose the lower level if it has not already been done (i.e., you have not already placed a page number in the lower box) and the higher level if the lower level has already been done.

3. *I think that I have been working at a high level but when I look at the work in the Portfolio I don't think it really shows that I am working at the high level.*

   This will happen and you have a couple of things you can do. First, you can discuss this with the course instructor; she may be willing to accept an oral demonstration and let you put the page number of the work that does not really show the high level in the high level box. An alternative is to add to your presentation of work so that the presented work does show that you were working at the high level.

---

[9]The as presented is important because for assessment it is only the work present in the Portfolio that can be used to establish the appropriate level.

[10]The systematic distinguishing, ordering and naming of type groups within a subject field, *Webster's Third New International Dictionary*

[11]For example, how much were you told about how to do the work and how much did you have to gin up yourself.

What Now?

When you created your portfolio structure you were asked to create several sections that have not yet been addressed. The section on Class notes is self explanatory but what about the others (Work Logs, Run Charts, Reflection Logs)? Should you be putting material into these sections? These are discussed in the next Part of this guide. If your course instructor asks you to keep Work Logs or Run Charts, you will need to read about them in Part IV. You will not initially be asked to create Reflection Logs and so you don't need to worry about them at this time.

After you have gone through the process of doing work and entering it into your Portfolio a few times, you will then find it worthwhile to read Part IV to get a more in depth coverage of this evaluation process.

Part IV -- Self Evaluation Process

The idea of an educational state was introduced in Part I and the start of a method that could be used to document (verify, show) that you have reached some educational state was presented in Part III. Now it is time to better understand the assessment process so you can master the self evaluation process.

For assessment the important questions that need to be answered are:

How do I know when I have reached some educational state? and

What do I have to do to show myself or someone else that I have indeed reached this educational state?

When you eventually become an expert at self evaluation you can and will fairly and correctly evaluate your actual educational state with little more than internal (i.e., in your brain) evidence. But this type *psychic* evidence will not be acceptable for classes or other situations where you must show others that you have reached a claimed educational state. In these situations you must supply documentation (information presented in some appropriate form) that demonstrates (shows) to the satisfaction of the reader that you have actually reached the educational states you are claiming. Even in those situations where you are doing only self evaluation, the preparation and presentation of this documentation generally leads to a fuller understanding of the material (see General Presentation Traits in Part II).

Before discussing the evaluation process it is necessary to understand the various documentation instruments (methods) that are used in the evaluation process and thus, these instruments are discussed first and then the process is discussed.

Documentation Instruments

The documentation process uses several different instruments (methods) for recording and storing your work. You must understand what each of these instruments is used for and how to use them before you can effectively produce them.

A Portfolio (or Design Notebook)

A portfolio is an organized collection of your work, technical and *non technical*, done in a class. It contains, in some logical sequence, all your out of class work, quizzes, tests, reports, projects, reflection and work logs (see below), class notes (optional), that is, everything done during the semester that relates to the class. Your portfolio becomes a collection of worked examples, examples you can refer to in later classes (or when out of school) when you need to review a topic learned in an earlier class.

Physically, portfolios are three hole, loose leaf binders although accordion files can also be used. Non loose leaf binders are not practical because it is not possible to remove or insert material, a necessary requirement. The number and order of the sections in the portfolio is not mandatory but the following suggested organization should help you get started if you are not sure how to start. Note, you may not understand what some of following sections are until you read on but once you do understand, you will then know where to put them.

Table 1 on the next page shows a suggested organization for your portfolio. As you can see the number of sections is not fixed but is a function of the Competency Matrix associated with the course. Once you understand your Competency Matrix you should be able to find a location (i.e., an appropriate section) in the portfolio for all the work you do.

The work within a section should also be organized so you can easily find it. To this end you will need to number all the pages of your work. Your page numbering must be unique (i.e., no two pages can have identical page numbers). This is probably most easily accomplished by using a numbering scheme that includes the section and location with in section (e.g., 1.2 is page two with in section 1).

A design notebook is a special type of portfolio, one containing all the technical work related to a design project. Since design projects are often done by teams the design notebook will include work from a variety of people. In a design notebook the sections will not be Learning Outcomes but rather separate technical tasks that are undertaken during the design process. Thus, for example, you could have sections related to Circuit Analysis, Structural Analysis, Propulsion, etc.

All the technical work in the portfolio/notebook must to the adhere to expectations for presentation of technical work presented in Part II.

Competency Matrix

In any class the instructor has a set of knowledge and skills (e.g., Engineering Design Process, Second Order Differential Equations, First Law of Thermodynamics, Teaming, etc.) that she wants to have the class learn. This set of knowledge and skills are known as the *learning outcomes* for the class. Learning outcomes are generally rather abstract and must be characterized by (i.e., defined in terms of) a number of more specific topics called *competency categories*. Depending on how specific the competency categories are, it may be possible (desirable) to further divide these competency categories.

However it is not enough to just define the learning outcomes and competency categories, the instructor must also decide, for each of these items, what cognitive and affective behavior levels the students should achieve. This crazy quilt of things to be learned and the levels they are to be learned to can be organized and presented in a Competency Matrix.

The general design of the matrix is quite simple. Along the left side of the matrix are the general course Learning Outcomes (sections in portfolio) along with each Outcomes' more specific Competency Categories (and Sub-categories if they exist). Along the top of the matrix are the various affective and cognitive behavior levels. Each cell in the matrix represents the intersection of a particular competency category or learning outcome and a particular cognitive level or affective degree. Part of a Competency Matrix for a Calculus Class is shown in Appendix B.

In looking at the Competency Matrix you will see black dots, gray areas, and white areas. The black dots show the cognitive and affective performance you are assumed to have reached when you start the class. The gray areas are the cognitive and affective performances that you are expected to achieve during the course of the semester. The white areas represent cognitive and affective performance that you may achieve but that are not ones explicitly expected to be achieved in the class.

At the start of a semester your matrix is empty. During the semester you will make entries in each of the gray (and perhaps white) boxes in the matrix. These entries are pointers to work in your portfolio that you feel support your claim of being at the educational state. What is actually put in these boxes will be explained in the Documentation Process Section (see below).

As a vehicle for documenting your educational state you will find that the matrix serves two purposes.

Section Number	Content
0	Course Competency Matrix
1	First Learning Outcome in Competency Matrix
.	.
.	.
.	.
N	Last of N Learning Outcome in Competency Matrix
N + 1	Class Notes
N + 2	Work Logs
N + 3	Run Charts
N + 4	Reflection Logs

Table 1
Suggest Portfolio Organization

1. It shows the cognitive and/or affective performance you have achieved in each of the course's competency categories, and
2. it shows where there is technical work to support the claimed educational state.

Work Logs

Work logs, as the name implies, keep track of the work you have done during the semester (i.e., the time spent on various class related tasks) . A sample work log template is shown in Appendix B. The log contains factual information related to your work. The log tells when the work was done, how much time was spent on the work, where the work is located in the Portfolio, and finally a code that clarifies the type of work was done.

Run Charts

It is sometimes necessary to monitor and track, over time, a quantity whose value changes with time (e.g., the outdoor temperature). In such situations it is often useful to present not only the current value of the quantity (e.g., temperature right now) but also the running, time averaged value of the quantity (e.g., average temperature over the last six hours). The name Run Chart comes from this type of presentation where you present the *running* history of the quantity's value. The time changing values can be periodically entered into tables but trends are hard to see in tables and, thus, this data is generally also shown on a graph, known as a Run Chart. A run chart is just a graph or plot that has time as the horizontal axis and the value of the time varying quantity on the vertical axis. The chart or plot must show the instantaneous values as well as the time averaged value. Generally the time averaged value will be shown as a curve superimposed on the instantaneous values.

A sample Class Attendance Run Chart that might be used as a general demonstration of Responding in a class, is shown in Appendix B. The chart shows time along the horizontal axis (i.e., class number) and the value of attendance along the vertical axes (yes = 1, no = 0). The data for each class is shown by the height of the bar while the running average is shown by the line. In the example shown the person missed class on the 3rd, 5th, and 11th day (bar has zero height). For the third class the running average dropped from 1 (perfect attendance) to 0.67 (attendance for two of three classes). The running average drops for each class not attended and slowly rises when classes are attended. You can see that the running average after twenty classes is about .86.

Reflection Logs

The last of the documentation vehicles are the Reflection Logs. These are the most difficult documents to produce and should only be attempted after you feel very comfortable with the evaluation process. In fact, the ability to create these logs is really a *final test* to demonstrate that you really are able to do evaluation. So what are these difficult to create logs?

The work contained in your portfolio displays activities you have undertaken during the semester. Some of this material shows Comprehension type activities, some shows Evaluation type performance, some shows Valuing type behavior, etc. As previously mentioned, traditionally it was the course instructor's task to sort through the work and decide what educational state was shown by the work. Deciding the state was done by (mentally) comparing the work with a set of Standards (Exemplars [12]) to see which Standard (Exemplar) the work most closely matched.

In the self evaluation mode, this task of matching work to performance Exemplars is done by you. You must look at the work, as presented in the portfolio, and select the most appropriate educational state Exemplar. Once you've completed this mental comparison and selection (i.e., this reflection on the presented work) you are ready to write a Reflection Log (see Appendix B for a template) which turns out to be a written explanation of why you selected the Exemplar you did. Such logs will contain traits from the selected Exemplar that you observed in the presented work. The logs also

[12]Exemplar - that which serves as a pattern, especially an ideal pattern

often try to show that the work is not a member of other possible Exemplars. These logs are meant to be informative, telling how you determined the educational state. When well written, they will be persuasive, convincing people that you do understand the evaluation process for the educational state selected.

The log need not look like the template shown in Appendix B but it should contain the same information. The log must have an identifying entry number and it must be clear which competency category (i.e., row(s) in the Competency Matrix) and Level of Learning and/or Degree of Internalization (i.e., columns in the Competency Matrix) are being addressed. Additionally, it must be clear where in the Portfolio the technical work being discussed is located. Finally, the log must contain the paragraph(s) of reflection. You may find that the reflections require more space than is given on the form, in which case you can append the necessary additional pages to the log entry.

The Self Evaluation Process

Now that you are familiar with the various documentation instruments it is possible to discuss the process that will let you complete your Competency Matrix (i.e., let you fill in each gray box). This section describes a general, self evaluation process, along with two slightly different implementations of the process.

The general self evaluation process consists of the following six steps:

1. generate and present evidence of activities or abilities,
2. compare your evidence to a set of Abilities or Activities Exemplars defined using a predefined hierarchy of learning,
3. pick out the Exemplar that best fits your evidence,
4. the selected Exemplar defines your current educational state,
5. explain your Exemplar selection process, and
6. fill in the gray boxes in the Competency Matrix.

Details about step 1, steps 2, 3, and 4, taken together, and steps 5 and 6 follow.

Generating and Presenting Evidence (step 1)

Before steps 2, 3, and 4 of this process can be done there must be activity and some sort of memorialization of the activity. Thus, the first step in documenting your educational state is the generation, collection, and presentation of evidence that can be used to show that you have in deed reached some educational state. The particular work you decide to do (i.e., the problems you solve, the way you solve them, and the way you present them) is influenced by the motivation you have for doing the work. Several different motivations are possible. First, the work may be motivated strictly by your desire to have examples showing that you are at some educational state (e.g., doing out of class assignments assigned by the class instructor). Second, the work may be generated strictly because you are solving a self-generated, technical problem that you have an interest (need) in solving (e.g., working on a design project). Third, the motivation may be a combination of these two (i.e., working to solve self-generated problems but, incidentally, also using the work to show achievement of some educational state).

For courses that are not project intensive, most of the work done in the class is done for the first reason, generation of examples showing that you have *learned*[13] the material. This sounds fine but how many assignments come with a notation explaining what gray boxes in a competency matrix the assignment could be used to show mastery of? The truth is, there is generally not just one thing the assignment could be used for; with a little imagination, most assignments can be used for a wide

[13]achieved some cognitive and/or affective behavior level

variety of competency categories and several different levels or degrees. You can do an assignment to show Knowledge or Analysis depending on how you choose to do and present the work.

Learning to do this mapping of assignment to matrix and matrix to assignment (i.e., learning to recognize the learning potential in an assignment) is not necessarily intuitive and takes some skill and thought. When you are first learning how to do self evaluation, the course instructor will discuss with you how her assignments are related to the matrix and what gray boxes you could reasonably go after if the work were done. As you gain familiarity and skill at doing self assessment you will find the course instructor will tell you less and less, letting you do more of the determination of the assignment's potential. You should eventually reach a point where you actually *mold* the assignment to make it fit your immediate matrix needs.

For project intensive courses the work done is primarily of the second kind, self generated problems, presented according to expected standards, and located in a Design Notebook. However, since the work is part of a course with specified educational states (gray boxes), some of the technical project work will have to also double as proof of achieving these specified states. You will find that, for some of the educational states you are striving to demonstrate, the standard vanilla notebook presentation of the technical work is not sufficient; the vanilla presentation fails to show the educational state you were actually operating at. It is relatively easy to present work that actually requires critical thinking (Analysis, Synthesis, Evaluation Levels of Learning) in a form that looks like Comprehension. In such cases you will need to augment the standard (vanilla) presentation so the work more clearly reflects the educational state you were really working at.

Exemplar Selection (steps 2, 3, and 4)

The Exemplars you are to use in steps 2, 3, and 4 are the various Levels of Learning and Degrees of Internalization defined by the two educational objectives taxonomies. You are to use the write-ups found in Appendix A as the *definitions* of these behavior states. The task of selecting the appropriate Exemplar consists of reading the various definitions and descriptions of activities associated with each Exemplar and comparing these activities with the activities that have been presented in the previous generation step.

For example, suppose you were in a Calculus class, working assigned, single concept problems, located at the end of a section concerning instantaneous velocity; what educational state does this type of activity suggest? Consider the cognitive domain first. Looking in Appendix A you see that for Knowledge, you would be expected to: define terms, read material, take simple recall quizzes. None of these activities seem to match what you have been doing. Looking at the next Exemplar, Comprehension, you see things like: work assignments in which the appropriate approach is evident, describe the results of working a problem, restate an idea in your own words. You also see that a typical work product is well presented homework. This is not too bad, at least there are some matches (e.g., worked problem, discussed results). Before settling on this Exemplar, however, you should consider the next higher one, Application. Here you see that the activities are similar to those of Comprehension with the major difference being the source of the solution method used is not immediately evident. You must now decide whether the method you used in solving the problem was *given* to you or whether you remembered the method from some other source or time. Problems at the end of chapters and sections are almost always of the first type and thus it seems clear that this work is evidence of working at the Comprehension level for competency categories associated with instantaneous velocity.

What about the affective domain? The process is identical. Consider the lowest degree, Receiving. From Appendix A you see that at Receiving you: listen, read, make notes of topics or items contained in the lecture, reading or classroom activity. This does not sound like what you have been doing; it is too passive. You have been *doing*. Looking at the next degree, Responding, you see here you are: calculating, answering questions in class, working instructor assigned problems. This sounds promising; again there is at least a partial match between what you did and the list of possible activities (i.e., doing assigned work). Looking at Valuing, you see that at this degree you believe the ideas of instantaneous velocity helps solve problems, that you can justify this belief, that you are

concerned when people express skepticism about instantaneous velocity. This Exemplar is possible and you will have to determine whether you are just responding or have developed a value for the material. Most likely in a Calculus Course, this is your introduction to the concept and you have not developed any of the characteristics associated with Value (i.e., you are at the Responding educational state).

As another example, suppose you have created a report that explains the process you used in designing a bridge for a design project your team has been working on. What cognitive level for failure analysis might this report and accompanying technical work support? A quick read through the lower cognitive levels shows partial matches for Comprehension and Application with Application winning out this time because you were not told exactly how to design the bridge and so had to recognize the utility of the solution methods you did use. Looking at the Analysis Exemplar, you see things like: able to break into parts, able to explain why the process works, able to explain causal relationships among the parts. You also see that the typical work product includes a report and in reading the report you recognize traits that match some of these things (e.g., breaking problem up into logical parts for studying different failure mechanisms). But you need to look at the next Exemplar, Synthesis where you see: put together parts, create a report or a process. Again, the material presented in the report shows at least a partial match, you have created the analysis process you used and, further, have explained this process in a report that you also created. So Synthesis is shown; is Evaluation justified? Looking at Evaluation you see activities of: compare, choose, evaluate, criteria, etc. If you considered several different, analysis methods and selected one of the methods based on a rational set of criteria, then you are operating at this top level; if you did not compare several methods but rather created a single method, then it would seem you were at the Synthesis and not Evaluation level for failure analysis.

Note: the decision about the higher levels of learning was based heavily on what was and was not in the report, that tied the technical work together and not so much on the presentation of the technical work. It is entirely possible that, if you were to only present the technical work, the only conclusion you could reach about the level of learning shown would be Comprehension.

It is difficult to pin down the appropriate affective degree; you have to read the descriptions and see where you fit. It will be either Responding or Valuing but, which it is, depends on you. It is possible that, if this project is a Senior Project, you have used these failure analysis methods enough that you do believe they are useful, in which case you are at the Valuing degree. If you don't see them as useful, then you are probably still at the Responding degree.

You can tell from these two, rather brief examples, how you might go about selecting an appropriate Exemplar. These examples, hopefully, also show that the matches between work presented and the various Exemplars will not necessarily be exact. You will have to make some decisions about when there are enough matches to justify the claim.

Explicit Justification of Exemplar Selection (step 5)

You must go through the previous comparison/selection process for every gray box in your Competency Matrix and every body of work you present, mentally comparing what you did and have presented with the Exemplars. Initially, because self evaluation is a new process and because you are not familiar with the Exemplars, this process will take time and you will not do it correctly. In most cases, during these learning stages of the process, your course instructor will tell you what Exemplar is possible when you work a problem. In this case your task becomes one of making sure your presentation supports the given Exemplar. As you learn how to generate the appropriate type of presentation you will be learning how to do the inverse problem, e.g., recognition of an Exemplar from a presentation of work. It is the inverse problem that was discussed in the previous section and is what you will need to learn how to do if you are to master self evaluation.

At some point in the class, after the instructor feels that you have indeed mastered the presentation of work for some Exemplar, the instructor may ask you to demonstrate that you truly understand the Exemplar, by having you explain why some set of work in your Portfolio shows mastery of the competency categories at the Exemplar of interest (e.g., *persuade me that you understand what is*

needed to be at the Analysis level of learning). The way you will do this is to create a Reflection Log for the work in question.

As discussed earlier, a Reflection Log discusses the process you went through in deciding which Exemplar most closely matches the presented work. A Reflection Log is not a discussion of the work, that is done as an expected part of the presentation of the work (see Part II). Rather a Reflection Log focuses on the general characteristics or traits of the work, characteristics or traits that allow you to match the work with an Exemplar. For example, if you were writing a log for the previous bridge design report work and were making a case that the presented work supported a claim of Synthesis level of learning you would need to look for:

1. the existence of well presented technical work (see Typical Work Products and Process Verbs for Synthesis)
2. the existence of a report or work that tied all the technical work together (see Typical Work Products for Synthesis)
3. discussion that was related to the creation of something (see Typical Questions and Process Verbs for Synthesis).

In the Reflection Log you would want to point out where in the presented work you could find examples of these three things. Thus, for example, you could point out the existence of the report as one of the things supporting your claim of Synthesis. You would need to point out some places within the report where the discussion focused on creation (addresses issue 3). You would probably also want to point out the absence of things associated with Evaluation.

How Many Reflection Logs

For this class you will only be writing Reflection Logs when the instructor requests it and this will most likely happen after you have demonstrated in your Portfolio, as evaluated by the instructor and your peers, that you can consistently prepare and present work at some level of learning. In other words you will be asked to write these Refection Logs only after you have demonstrated a Comprehension Level of Learning concerning the Exemplar of interest. You have to write at least one log for each level of learning (Exemplar). If the first log fails to show an adequate grasp of the issues associated with the Exemplar,(i.e., fails to show you are at Comprehension Level of Learning for the Exemplar) you will have to write another log, for a different body of work in your Portfolio.

Filling In The Competency Matrix Gray Boxes (step 6)

This is the last and by far the easiest step in the entire process. The filling in of the gray boxes should occur at a some what uniform rate during the semester. What you put in these gray boxes depends on whether they are affective or cognitive boxes.

Cognitive Gray Boxes

For the cognitive domain this last step is quite easy. After you have determined the appropriate Exemplar (LoL for the work), you simply enter the portfolio (Design Notebook) page numbers that contain the evidence supporting your claim. This would be the first page of the work or report. It could also be the page number for a figure or chart within a body of work.

Affective Gray Boxes

Collecting demonstration material for the gray affective boxes is a bit more difficult, especially for Valuing where the Exemplar uses terms like *believe* and *feel*, things not easy to capture in your presentation of work. This is the first year in which the affective domain has explicitly shown up on the Competency Matrix and hopefully, the class will learn something about how to document these affective boxes. However, until the class decides to do things differently, the gray affective boxes are to be handled as follows.

1. Receiving
   It seems very unlikely that you can operate at the cognitive Knowledge level without operating at the Receiving degree. Thus, by inference, you can claim proof of Receiving

any time you justify Knowledge. Put the same Portfolio page number entry in the Receiving gray box as you put in the Knowledge gray box.

2. Responding
   It again seems very unlikely that you can operate at the cognitive Comprehension level without operating at the Responding degree. Thus, by inference, you can claim proof of Responding any time you justify Comprehension . Put the same Portfolio page number entry in the Receiving gray box as you put in the Knowledge gray box.
3. Valuing
   These boxes are a bit tricky. Presentations of technical work, even high quality presentations, do not of themselves contain the sort of information that would allow a person to deduce whether or not you valued the process or methods being used. If you feel you have reached this degree of internalization then you will need to prepare a Reflection Log that explains why you have reached this degree. This Valuing Reflection Log will contain information, not found in the presentation of the work, but germane to establishing your claim of Valuing.

   It may be that you do not feel that you have reached the Valuing degree by the end of the semester. If this happens, prepare a Reflection Log that address the issue of why you have not reached Valuing and refer to that log in the Competency Matrix.

   For these Valuing Reflection Logs, you should enter the Reflection Log Page number into the gray box (you can also enter the Reflection Log item number in the gray box if there is room)

   Run Chart Competency Categories

You may find some of the competency categories in your Competency Matrix have been marked as *(run chart)* categories. This designation is given to those categories that cannot be documented with a single effort but require a semester long, accumulation of efforts to show achievement of the category. For such categories you will be maintaining a run chart that shows your semester long commitment and, at the end of the semester, you will place that run chart's page number in the competency matrix box.

When Can You Claim Level or Degree *Mastery*?

If for some competency category you show you can operate at an educational state once, does that mean you that in this class you would always operate at at least that state? That is, if you were to work a second problem using the same competency category would the second effort always be at the same educational state as the first effort? If the answer is maybe or maybe not, then how many times must you perform at some educational state before you can safely claim retention of the level (i.e., claim *mastery* [14]of the educational state).

This discussion of *mastery* is limited to the time period you are in this class and does not include what happens to your educational states once you leave the class. There is no question that, if you do not subsequently use the competency category items in future classes or work related activities, the educational states you achieve in this class will decay. The curriculum, of which this class is a part, has been developed knowing this time decaying nature of educational states and has been constructed to give you many opportunities, in a series of classes, to use the competency categories that need to have continual growth (or at least no decay) in their educational states. The expected educational states shown in the Competency Matrix for this class are consistent with either the

---

[14]Note this material is using mastery of a competency category at a level or degree and not mastery of the category, which generally implies being able to work, unconsciously at the highest cognitive level, i.e., being an expert of the category. *Mastery* , as used in this section, also does not have any performance speed attached to the meaning. *Mastery* does not mean that you have instant recall or the ability to instantly solve the problem at the educational state claimed.

educational states needed in further classes or the desired, BS graduate, life long levels of performance.

APPENDIX A
Activities at Various Cognitive Levels of Learning
and
Affective Degrees of Internalization

Printed December 4, 1994

Activities at Various Levels of Learning

KNOWLEDGE (INFORMATION)

How do I know I have reached this level?

I recall information. I bring to mind the appropriate material at the appropriate time. I have been exposed to the information and can respond to questions, tasks, etc.

What do I do at this level?

I read material, listen to lectures, watch videos, take notes and I am able to pass a test of knowledge on the subject area. I learn the vocabulary of the competency area, i.e., the terminology. I learn the conventions used.

How will the teacher know I am at this level?

The teacher will provide opportunities (either orally or in written tests), regardless of complexity, that can be answered through simple recall of previously learned material.

What does the teacher do at this level?

The teacher directs, tells, shows, identifies, examines the information necessary at this level.

What are typical ways i can demonstrate my knowledge?

1. Define technical terms by giving their attributes, properties, or relations.
2. Recall the major facts about a particular subject
3. List the characteristic ways of treating and presenting ideas (i.e., list conventions associated with the subject)
4. Name the classes, sets, divisions, and arrangements that are regarded as fundamental for a given subject field or problem.
5. List the criteria used to judge facts, principles, ideas.
6. Describe the method(s) of inquiry or techniques and procedures used in a particular field of study.
7. List the relevant principles and generalizations
8. Fill in the blank

Typical Work Products

1. hand written answers to Knowledge quizzes (True/False, Yes/No, multiple choice, fill in the blank)
2. lists of definitions

Process verbs:

define	label	listen	list
memorize	name	read	recall
record	relate	repeat	view

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

COMPREHENSION (UNDERSTANDING)

How do I know I have reached this level?

I comprehend and understand what is being communicated and make use of the ideas but without relating them to other ideas or material. I may not yet understand the fullest meaning. I understand what others are discussing concerning this idea. This level requires Knowledge.

What do I do at this level?

I successfully work assignments in which the appropriate approach is evident either because of material in the problem statement or because of the problem's relative location in the book to the appropriate method. I translate information into my own words (translation from one level of abstraction to another). I translate symbolic information (e.g., tables, diagrams, graphs, mathematical formulas, etc.) into verbal forms, and vice versa. I interpret or summarize communications (written/graphical/oral). I determine implications, consequences, corollaries, effects, etc. that are extensions of trends or tendencies beyond the given data.

How will the teacher know I am at this level?

The teacher will often ask questions or give tests that can be answered by merely restating or reorganizing material in a rather literal (clearly stating the facts or primary meaning of the material) manner to show that I understand the essential meaning, e.g., give the ideas in your own words.

What does the teacher do at this level?

The teacher demonstrates, works problems, listens, questions, compares, contrasts, and examines the information and your knowledge of it.

What are typical ways I can demonstrate or can show on my own my comprehension and understanding.

1. Read (Know-How type) problems, know what is being asked for, and successfully work the problems
2. Clearly chronicle the process used in working the problem
3. Clearly describe the results of working a problem
4. Draw conclusions (interpret trends) from the results of solving a problem
5. Compare/contrast two different problems (i.e., what things are the same?/what things are different?)
6. Restate an idea, theory, principle in your own words.

Typical Work Products

1. hand written answers to Comprehension quizzes and exams (problems, multiple choice)
2. work associated with homework problems, presented with enough information that it is clear what the problem is, why it is being worked, what general method is being used, and what the results of the work mean

Process verbs:

describe	explain	express	identify	locate	recognize	report
restate	review	tell	work			

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

APPLICATION (THINKING)

How do I know I have reached this level?

I have the ability to recognize the need to use an idea, method, concept, principle, or theory without being told to use it, i.e., I have the ability to use ideas, methods, concepts, principles and theories in new situations. I know and comprehend the information and can apply it to a new situation. I also have the ability to recognize when a certain task, project, theory or concept is beyond my current competency. Application requires having Knowledge and Know-How.

What do I do at this level?

I work problems in which the solution method is not immediately evident or obvious. I take knowledge that has been learned at the Knowledge and Know-How Level of Learning and apply it to new situations. I solve problems on my own and make use of other techniques. This requires not only knowing and comprehending information, but deep thinking about the usefulness of this information and how it can be used to solve new problems that I create or identify.

How will the teacher know I am at this level?

I will show the teacher through my work that I am involved in problem solving in new situations with minimal identification or prompting of the appropriate rules, principles, or concepts by the teacher. The teacher will be able to ask general questions like, *How much protection from the sun is enough* and I will know how to attack the problem.

What are the typical ways I can demonstrate or show, on my own, my application of knowledge and understanding?

1. Solve problems that require recognition of the appropriate concepts, theories, solution techniques, etc.
2. Apply the laws of mathematics (chemistry, physics, engineering) to practical situations
3. Work *project type* problems

Typical Work Products

1. work that looks very much like that produced for Comprehension plus some additional information that shows you recognized the need to use the solution methods utilized

Process verbs:

apply	demonstrate	employ	illustrate
interpret	operate	practice	recognize

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

ANALYSIS (THINKING)

How do I know I have reached this level?

I can explain *why*. I can examine, methodically, ideas, concepts, writing etc. and separate into parts or basic principles. I have the ability to break down information into component parts in order to make organization of the whole clear. Work at this level requires having Knowledge and Know-How Levels of Learning (Application is not required).

What do I do at this level?

I analyze results by breaking concepts, ideas, theories, etc. apart. I can explain the logical interconnections of the parts and can develop detailed cause and effect chains.

What does the teacher do at this level?

The teacher probes, guides, observes, and acts as a resource.

What are typical questions I can pose for myself to answer that will demonstrate or show my Analysis Level of Learning?

1. Why did this (result) happen?
2. What reason does she give for her conclusions?
3. Does the evidence given support the hypothesis, the conclusion?
4. Are the conclusions supported by facts, opinions, or analysis of the results?
5. What are the causal relationships between the results for the whole and the parts?
6. What are the unstated assumptions?

Typical Work Products

1. hand written or word processed answers to Analysis exams (problems, multiple choice, essays)
2. work that looks very much like that produced for Comprehension but it has some additional discussion of the work. The type, amount, and depth of discussion (see items above) is what distinguishes the work from Comprehension

Process verbs:

break apart break down examine explain

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

SYNTHESIS (THINKING)

How do I know I have reached this level?

I have the ability to put together parts and elements into a unified organization or whole that requires original, creative thinking. I recognize new problems and develop new tools to solve them. I create my own plans, models, hypotheses for finding solutions to problems. This Level of Learning requires Knowledge, Know-How, Application and Analysis Levels of Learning.

What do I do at this level?

I put ideas together to create something. This could be a physical object, a process, a design method, a communication, or even a set of abstract relations (i.e., mathematical models). I produce reports (written/oral) that create a desired effect (e.g., information acquisition, acceptance of a point of view, continued support, etc.) in the reader (listener). I generate project plans. I propose designs. I formulate hypotheses based on the analysis of pertinent factors. I am able to generalize from a set of axioms, principles.

How will the teacher know I am at this level?

I show that I can combine ideas into a statement, plan, product, etc., that is new for me; e.g., can I develop a program that includes the best parts of each of those ideas?

What does the teacher do as this level?

The teacher reflects, extends, analyses, and evaluates.

What are the typical questions I can answer that will demonstrate or show my synthesis?

1. Can I create a project plan?
2. Can I develop a model?
3. Can I propose a design?

Typical Work Products

1. hand written or word processed answers to Synthesis exams (problems, multiple choice, essays)
2. work that looks very much like that produced for Comprehension but it has some additional discussion of the work. The type, amount, and depth of discussion (see items above) is what distinguishes the work from Comprehension

Process verbs:

arrange	assemble	collect	compose
construct	create	design	formulate
manage	organize	plan	prepare
propose	set up	write	

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

APPRECIATION/EVALUATION (WISDOM)

How do I know I have reached this level?

I have the ability to judge and appreciate the value of ideas, procedures and methods using appropriate **criteria**. To work at this level requires having achieved Knowledge, Know-How, Application, Analysis and Synthesis Levels of Learning.

What do I do at this level?

I make value judgments based on certain considerations such as usefulness, effectiveness, and so on. Based on information gained through application, analysis, and synthesis I can rationally select a process, a method, a model, a design, etc. from among a set of possible processes, methods, models, design, etc. I evaluate competing plans of action before actually starting the planed work. I evaluate work based on internal standards of consistency, logical accuracy, and the absence of internal flaws (e.g., I can certify if design feasibility has been demonstrated in a report). I evaluate work based on external standards of efficiency, cost, utility to meet particular ends (e.g., I can. certify that design quality has been demonstrated in a report).

How will the teacher know I am at this level?

I can demonstrate that I can make a judgment about something using some criteria or standard for making the judgment.

What does the teacher do at this level?

The teacher clarifies, accepts, harmonizes, aligns and guides.

What are typical statements and questions I can respond to that will demonstrate or show my appreciation/evaluation?

1. I can evaluate an idea in terms of ...
2. For what reasons do I favor...
3. Which policy do I think would result in the greatest good for the greatest number?
4. Which of these models (i.e., modelling approaches) is best for my current needs?
5. How does this report show that the design is feasible?
6. How does this report show the quality of the design?

Typical Work Products

1. hand written or word processed answers to Evaluation exams (problems, multiple choice, essays)
2. work that looks very much like that produced for Comprehension but it has some additional discussion of the work. The type, amount, and depth of discussion (see items above) is what distinguishes the work from Comprehension

Process verbs:

appraise	choose	compare	estimate (quality)	evaluate
judge	predict (quality)	rate value	select	

Modifications by B. McNeill of David L. Langford's definitions of Levels of Learning in, *Total Quality Learning Handbook*, Langford Quality Education and B. Bloom et. al's *Taxonomy of Educational Objectives*, Longmans, Green and Co., 1956.

RECEIVING (ATTENDING)

The degree of Receiving ranges from simple awareness, to a willingness to receive, and finally to controlled or selected attention. You must first become aware of information, concepts, theories, etc. before you can decide whether or not you are willing (and able!) to receive this information, etc. The next decision is naturally whether or not this information, etc. is important enough to merit your controlled or selected attention.

What do I do at this degree?

At this degree of internalization I am concerned only with my conscious recognition of the existence of certain phenomena and stimuli (i.e., I am willing to receive or attend to these phenomena and stimuli). I am willing to listen to lectures, read books, or watch videos and am aware[15] of the material being presented in the lectures, books, videos[16]. I have written notes or sketches related to the presentation.

How do I know I have reached this degree?

At the end of a lecture, book or video, I can select from a set of topics the ones that were presented in the material. I can list or briefly summarize points from the presentation.

Process verbs:

concentrate	feel (touch)	listen
pay attention	read	recognize
remember	smell	watch

[15]Does not imply Comprehension or Knowledge of the material only awareness

[16]A point of caution: being willing to receive may not actually ensure that you are receiving. You do not come to class *de novo*. Because of previous experiences (formal or informal), you bring a point of view which may facilitate or hinder recognition of the teacher presented phenomena. These *a priori* points of view (also referred to as paradigms or learning styles) can filter your attending causing you to actually not receive the intended material, even when you are willing to receive the material.

Modifications and paraphrasing by B. McNeill and L. Bellamy of David Krathwohl et. al's *Taxonomy of Educational Objectives Book 2 Affective Domain*, Longman, 1964

RESPONDING

The degree of Responding ranges from simply agreeing to respond, to a willingness to respond, and finally to actually getting some satisfaction from responding to directions, requests, information, concepts, theories, etc.

What do I do at this degree?

I learn by doing[17]. I answer questions in class when called upon. I do the work assigned by the instructor for this class. I attend and participate in team meetings organized by the instructor. Outside of class, I spontaneously discuss course material with classmates and especially with friends who are not classmates. I ask questions in class. I prepare notes on my reading assignments. I reorganize and integrate my class notes with my reading assignment notes. I participate in the learning activities created by the instructor, both those inside the classroom and those outside of the classroom. I make an effort to find the class material interesting and useful. I may use it as the basis of written or oral reports in other classes [18].

How do I know I have reached this degree?

I feel comfortable with my team (i.e., I know that I am contributing at least what is expected by my teammates). I meet the class deadlines. I invest the expected level of effort for the class. I attend class regularly and arrive on time. I have work products or deliverables, that I have constructed for this class, that are well organized and accessible.

Process verbs:

calculate	discuss	draw
integrate	make	organize
play	sketch	talk
write		

---

[17]As paradigms can color what you actually receive, fear can keep you from responding, even when you are willing. Fear of failure (as judged by an instructor or peer), fear of looking silly, fear of ridicule, fear of missing the point, fear of punishment, fear of a poor grade, fear is a powerful, extrinsic DEmotivater which you will have to address before you reach the Responding degree of internalization.

[18]Responding is still a rather low level of commitment and it would be incorrect to say that you *value* the material or that you actively displayed an *attitude* toward the material.

Modifications and paraphrasing by B. McNeill and L. Bellamy of David Krathwohl et. al's *Taxonomy of Educational Objectives Book 2 Affective Domain*, Longman, 1964

VALUING

The degree of Valuing ranges from simply accepting the values presented by the instructor, to preferring these values, and finally to actually making a commitment to these values. The values of interest here are the directions, requests, information, concepts, theories, etc. specified in the written course material or orally by the instructor during the course.

What do I do at this degree?

I frequently use the material (i.e., skills, methods, knowledge, etc.) that I have learned to solve problems. I may try to teach the material to people who are not familiar with the material or people who are having difficulty understanding the material. I use the material in activities unrelated to this class. I form or take part in study groups to further understand the material. I may challenge people who are skeptical about the material in an effort to help them eliminate or at least reduce their skepticism.

How do I know I have reached this level?

I believe the material I have learned is useful and helps me solve problems. Also, I can justify or explain this belief both to my self and to others. I make a concerted effort to obtain more information about the class material (e.g., obtain additional books, watch extra videos, attend other classes or seminars). I am concerned when people express their skepticism or doubts about the material and its value or usefulness. I am comfortable working in teams or working alone. I am interested in the class material and demonstrate curiosity, honesty, integrity and truthfulness in dealing with others and in the work products or deliverables I produce for the class.

Process verbs:

care convince use

Modifications and paraphrasing by B. McNeill and L. Bellamy of David Krathwohl et. al's *Taxonomy of Educational Objectives Book 2 Affective Domain*, Longman, 1964

APPENDIX B
Competency Matrix
Reflection Log Template
Work Log Template
Sample Run Chart

Sample Competency Matrix

Before Class • After Class

Learning Outcomes	Competency Categories	comp #	Affective Degree: Receiv-ing	Respond-ing	Value-ing	Cognitive Level: Knowl-edge	Compre-hension	Appli-cation	Analy-sis	Syn-thesis	Evalua-tion
1. differentiation	exponential functions	1.1									
	hyperbolic functions	1.2									
	implicit	1.3									
	polynomials	1.4	•								
	trigonometric functions	1.5									
2. team meetings	code of cooperation	2.1									
	constructive feedback	2.2									
	devils advocate	2.3									
	gatekeeper	2.4									
	norms	2.5									
	team facilitator	2.6									
	team leader	2.7									
	team member	2.8									
	time keeper	2.9	•			•					

Reflection Log Template

Log Entry Number:
Competency Category(s):
Level of Learning and/or Degree of Internalization Claimed:
Location of Supporting Work
Reflection

Log Entry Number:
Competency Category(s):
Level of Learning and/or Degree of Internalization Claimed:
Location of Supporting Work
Reflection

Work Log Template

Log Entry Number	Name of Person Doing the Work	Date	Total Time Spent (decimal hours)	Location of Work in Portfolio	Work Code

Work Code	Definition	Work Code	Definition
1.		5.	
2.		6.	
3.		7.	
4.		8.	

Class Attendance