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ABSTRACT

This study examined the effects of non-traditional instructional methods on student learning in an engineering course at the University of Texas at El Paso. The summer 1993 material selection course enrolled 33 students, the majority of whom were Hispanic Americans. Instead of the traditional lecture method, the course employed student project groups, video presentations of actual manufacturing processes, computer exercises, vocabulary quizzes, and homework to enhance student retention of the course content. An extensive evaluation of the course examined the relationships between course grade and: (1) Scholastic Aptitude Test (SAT) scores; (2) grade point average (GPA); (2) meeting of course prerequisites; (3) homework grades; (4) vocabulary quiz grades; and (5) group project grades. The evaluation found that SAT and GPA accounted for 61 percent of the variance in course grades. It also found that while all the students who met the course prerequisites received a grade of A, B, or C, while 8 of the 19 students who did not meet the prerequisites received a grade of D or F. Homework grades had a slightly negative effect on course grades, while group project grades had a significant positive effect on course grades. Student and instructor reaction to the course format are discussed. (Contains 74 references.) (MDM)

EFFECTS OF NON-TRADITIONAL TEACHING ON RETENTION AMONG PREDOMINANTLY HISPANIC ENGINEERING STUDENTS

An Evaluation Funded by the National Science Foundation
And by the University of Texas at El Paso
Undergraduate Course and Curriculum Program

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THE EFFECT OF NON-TRADITIONAL TEACHING ON RETENTION AMONG PREDOMINANTLY HISPANIC ENGINEERING STUDENTS

Introduction

Failure to internalize and apply technical material has always been a complaint of teachers about their students. Students at the University of Texas El Paso experience this difficulty in ways that limit our ability to teach technical subjects at an acceptable level. Our students for the most part are first generation college students with primarily Hispanic family origins. The problem is intensive in mathematics problems faced by students of Metallurgical and Materials Engineering (M&ME). McClure (1991-92) surveyed local high school mathematics curricula, testing patterns and teaching methods. His results indicate that, as high school students, prospective engineering students were well prepared in high school to cope with engineering education. Eighty-five percent of the students took four years of high school mathematics, and sixty-five percent took calculus. They attained high school grades of A or B on tests that were judged to be rigorous and demanding. Nevertheless, after a summer vacation of three months, when students entered college and were given a mathematics placement test, sixty-six percent scored so poorly that they were required to retake one to two years of high school mathematics before entering the engineering curriculum. Their career as an engineer was disrupted and often abandoned.

Inadequate retention of knowledge and skills previously learned compounds throughout students' degree program to the extent that professors simply cannot count on students understanding basic material learned in previous courses. For example, one of our colleagues who teaches physical metallurgy to juniors, finds it necessary to spend the first two weeks of the semester, including six hours of time that should be devoted to laboratory work, in intensive review of the material in the prerequisite course taught the previous spring. Since the students are capable of learning material and passing tests year after year in high school and in college, we wished to address the problem from the perspective that students operate more in short term memory than they internalize or retaining much of what they need to know as prospective professional engineers from one course to the next. McClure proposed to alter his classroom teaching and management to encourage retention rather have students make short term gains and not remember the course content beyond examinations.

One thesis is that the traditional lecture, which places the student in a relatively passive position, must be replaced by an environment in which the professor transfers responsibility for active learning to the students. Students were encouraged to take an active versus a passive role within the classroom and in additional assignments outside the classroom. The course material was reorganized and was to be presented in a structured framework representing the structure of knowledge (epistemology) of materials engineering.

The University of Texas at El Paso is typical of urban public universities in that admission standards are not high and sixty percent of our students work twenty or more hours per week. Students' must balance family and job obligations. Consequently, they do not have many opportunities to interact with their peers outside class in sharing classroom experiences and helping each other with material that is not well understood. They rarely have opportunities to "talk engineering" outside the classroom. Sixty percent of our graduates are the first of their family to attain a university degree so they have little chance at home to discuss technical material or to relate the material to their parents' professions. Furthermore, our sixty-five percent Hispanic enrollment reflects the ethni makeup of El Paso. Thus, our students come from a culture in which a verbal exchange of an academic nature between young people and their parents and teachers is not frequently the case, and there is normally minimal classroom discussion in high school science courses and in university science courses.

In summary, several factors, some peculiar to UTEP and some common to engineering students in general, encourage a passive learning environment in which students listen to lectures for most of their college career and only in their senior year are asked to design a project using their accumulated knowledge.

It is our hypothesis that by (1) increasing student participation in the classroom, (2) using video presentations of actual manufacturing processes, and (3) using commercial computer programs like those used by professional engineers, (4) engaging students in a group development project, and (5) establishing a computerized data base of classroom course materials for students to access from e-mail terminals or laboratory computers, classroom academic material and expected skill development will be enhanced.

The first goal of this proposal is to test this hypothesis in a high profile course that will be a model for teaching in other courses.

A second goal is to establish a formal relationship between faculty in the College of Education and the College of Engineering to share teaching expertise among the two colleges to benefit science teaching at the high school level and at the university level.

Potential Impact

Material Selection (MET 3203) is a required course for materials, mechanical, and civil engineering sophomores. It is taught each semester and during the summer to classes averaging forty-five students. The course provides a background for these students in metals, plastics, and ceramics and relates the properties of these materials to their structure. Students majoring in materials engineering, of course, take additional courses in later semesters. McClure has taught this course five times and is generally regarded as a good teacher who, according to student evaluations, "emphasizes concepts rather than rote memorization." The course was taught in the traditional lecture style although students were often, perhaps ten times per lecture, asked to answer questions or amplify points. Nevertheless, most students never speak in class during a semester.

Similar courses are taught in engineering schools throughout the country. Consequently, the textbook market is very competitive, and well-written textbooks make lectures largely redundant as an information dissemination technique. Thus, Materials Selection would be a good course to test a new teaching approach.

The influence of this experiment will be considerable for the university. Approximately two thirds of engineering majors at UTEP take this course so most of the engineering students will be reached by this course. It is anticipated that the course will model a modern engineering course as a replacement for the more traditional lecture and problem solving course. Students, however, are very conservative in their evaluation of courses and exert pressure through their course evaluations to maintain an unimaginative rote learning style of teaching. For example, McClure is frequently criticized because his tests are not identical to the homework problems. By exposing students as sophomores to improved learning approaches, it is hoped that they will demand better teaching in subsequent courses.

Methods

Introducing new teaching approaches in established disciplines is difficult because innovative courses are often perceived to be less efficient in covering course material than traditional lecture courses. Lecturing is efficient in covering material if not efficient in promoting learning. PI's in this project understand that to improving learning effectiveness is not the same as effective lecturing. The PI's are convinced that there is little purpose in covering material if almost none of it is retained beyond the final examination. We also think that a justifiable scope of concepts and professional engineering skills must be taught, and the students tested to verify that learning has occurred. Therefore, we judge that at least two-thirds of the material normally covered is a reasonable scope of material to be covered in the experimental course.

Instructional Strategies

Project instructional strategies developed by the principal investigators represent a combination of adapted procedures drawn from three prominent instructional theorists. First, it is well established that retention of cognitive material in science and mathematics is aided by the internalization of the structure of knowledge or epistemology of the discipline (Scandura, 1977). Stevens and Scandura (1987) presented a model of how this theory may be applied to a science lesson. "The greatest strength of the SLT is its ability to allow an instructor to select quickly and accurately content and sequencing requirements for training that will provide only the instruction needed by the learner" (Stevens and Scandura, 1987, p. 165). Rationale for this strategy was used to structure the curriculum and course lessons which were intended to provide a basis for developing cognitive frameworks for students in learning the course content and skills.

Structural Learning Theory (SLT) combines three separate approaches to the study of problem solving into one comprehensive theory (Scandura, 1977). SLT acknowledges the important role that content, cognition, and individual differences play in problem solving, but Scandura also believes that studying any one of these approaches exclusively is inadequate. A dynamic interrelationship among the three approaches is a key to developing a theory of problem solving.

Researchers who have taken the content approach to the study of problem solving are interested in the knowledge one needs to solve problems in specific domains. Content specialists believe this is necessary in order to study problem solving itself and in order to study how to train people to solve problems (Scandura, 1977). These researchers are often the computer scientists and the subject matter educators who are focused narrowly on their own fields; they may borrow ideas from other fields, but they rarely combine and create new theories.

In the cognition approach, psychologists are most interested in the process of problem solving itself. Introspection, informal clinical observation, and verbalization during problem solving experiments are some of the techniques that have been used (Scandura, 1977). Some of these experiments have had interpretation difficulties that have limited the success of this as a solitary approach. However, most psychologists generally agree that there are several prerequisites to a learner's successful problem solving: he must understand the problem; he must identify suitable subgoals to the problem; he must retrieve relevant information from his memory; he must differentiate between relevant and irrelevant information; he must carry out the procedure correctly; and he must verify results (Scandura, 1977).

Individual differences in problem solving had been a neglected area of study, but since the 1960's , specifically the advent of computer science and artificial intelligence, it is being examined more closely. Investigators wish to determine to what individual differences can be attributed, and they are looking at physiological capacities, physical maturation, and identifiable knowledge that can be taught and learned (Scandura, 1977).

SLT emphasizes the importance of deciding what to teach. It has three unique contributions: the selection of content, the require-ment of mastery of each equivalence class (i.e., homogeneous type of problem), and the sequencing prescription (Stevens & Scandura, 1987). It is a comprehensive theory in that it deals with both the instructor and the learner, and it incorporates the three traditional approaches (content, cognition, and individual differences) and their relationships (Ehrenpreis & Scandura, 1977).

Scandura believes that all content should be presented in the form of rules. Each rule has a domain, a range, and an operation, and he specifically defines each. The domain "is the content upon which a learner operates to produce results specified in objectives" (Stevens & Scandura,1987, p. 163). The range is " the set of structures (solutions) associated with a rule" (Scandura, 1977, p. 154). The operation (procedure) is the " sum of all decisions and subsequent actions by a learner to produce a specific range element" (Stevens & Scandura, 1987, p.154).

To design a lesson based on the SLT one must analyze the structure of the content. The analysis identifies the cognitive processes (rules) needed to learn the lesson objectives; the rules become the content to be taught (Stevens & Scandura, 1987). The SLT can also be applied to curriculum construction. Every behavioral objective has a corresponding call of tasks that can be solved by applying a rule. "The greatest strength of the SLT is its ability to allow an instructor to quickly and accurately select content and sequencing requirements for training that will provide only that instruction needed by a learner." (Stevens & Scandura, 1987, p.165).

Ehrenpreis & Scandura (1977, p. 392) list six steps to curriculum construction based on the SLT.

1. Select text materials to analyze.
2. Identify all tasks implicit in the text material.
3. State those tasks as behavioral objectives.
4. Write rules for solving each of the tasks.
5. Identify all parallels among those rules; the parallels indicate common basic structure, which is then the foundation for creating higher-order rules.
6. Eliminate those rules that are derivable by application of the higher-order rules to other rules in the characterizing set.

SLT was modified in the lesson guide for students that accompanied the lesson on "Mechanical Testing and Properties" which also appears as the title of Askeland's (1984) textbook chapter six. The adapted lesson guide appears below.

Tensile Test

1. Define tensile test.
   --Explain tensile test using transparencies on the testing and the stress-strain curve.
   --Pass around various specimens.
   --View the video on mechanical testing; review the portion on tensile testing after explaining the importance of knowing tensile results (as far as selecting a material).
2. Identify a typical specimen (0.505 in. diameter, 2 inch gage length).
3. Define engineering stress algebraically.
   --Calculate problem # 1, 2.
4. Define engineering strain algebraically.
   --Calculate problem # 3.
5. Convert load / gage length data (from a given table) to engineering stress and engineering strain.
6. Plot a stress-strain curve.
   --Using the data in problems 11, 13 and 15, plot the curves.
7. Differentiate between elastic deformatiion and plastic deformation.
8. Define yield strength.
   --Calculate problem # 5
9. Explain how knowledge of a material's yield strength can effect that material's selection for use in a product.
10. Define tensile strength.
    --Calculate problems # 13 c, 15 a.
11. Define necking.
12. Compare yield strength and tensile strength.
13. Define true strain and include the formula.
14. Define true stress and include the formula.
15. Explain the relationship between true stress / true strain and engineering stress / engineering strain.
16. Explain the stress / strain behavior of materials that are a) brittle, b) moderately ductile, and c) highly ductile.
17. Define modulus of elasticity (Young's modulus).
    --Calculate problem #11 a; 13 a, 15 c

18. Define ductility, % elongation, and % reduction in area.
   --Work problem #9, #15 d.
19. Explain the effect of temperature on tensile properties.
   --Work problem #18 a,b,c.

Producing specific classroom events grounded in sound pedagogy was a second major consideration of the project. It is the position of the PI's that presentation of the content and skills in a way that promotes learning will aid in accomplishing the goals of the project. Gagné (7) identified nine events of instruction which provide support of learning. He suggested that the nine events be adapted to curriculum requirements by level of abstraction and to needs of students in learning course content. The nine events are (1) gaining attention, (2) informing learners of the lesson objectives, (3), stimulating recall of prior learning, (4) presenting stimulus materials with distinctive features, (5) providing learning guidance, (6) eliciting performance, (7) providing informative feedback, (8) assessing performance and (9) enhancing retention and learning transfer. Gagné events were used as an overall guide or checklist for conducting lessons in the classroom and developing activities in the laboratories to reinforce the student learning. The seauence of Gagné events in each lesson was intended to respond to the cognitive levels of abstraction of the content and skill level to be learned.

Third, there is strong evidence and tradition supporting the use of inquiry as an instructional method when the goal is for students to engage in abstract thinking and to learn the importance of inquiry reflection to science. Socratic dialogue has specific uses in the teaching of science and was a strategy that McClure wished to perfect as a technique. Abercrombe (1960) in an experiment related to the goals of this project demonstrated that inquiry based instruction could be adapted beneficially to x-ray analysis by medical students at Cambridge University. More recently the technique was advocated in science learning by Collins (1987). "Inquiry teachers have two overall goals. One is to teach deep understanding of a particular domain so that students can make novel predictions about the domain. The other is to teach students to be good scientists so they can learn to construct general rules and theories on their own, and to be able to test them out. (3, p. 183)" Collins (1987) elaborated the use of this technique in a lesson designed to teach the focal properties of lenses. Thus, the combined use of instructional research and theoretical pedagogy from a number of sources is thought to be a strength of this project. Documentation of successful and unsuccessful procedures has implications for further research scientific learning as well as the feedback that is necessary for perfecting those techniques within the project.

Several techniques were used to encourage student participation in the events of the classroom. One activity was the formation of discussion and project work groups. In particular , each student was assigned to a five member group. All groups had at least one materials, one mechanical, and one civil engineer. Each group was responsible for the design of a course related project. Students were assigned a complex design project involving various materials. They had access to computer programs such as the ASM Materials Selector that they used in specifying materials. Students have had a CAD/CAM course as a prerequisite so drawings as well as specifying fabrication techniques were required. Three possible projects were available for selection. The projects were to design a Baja race car, to design a bicycle, or design an ecologically sound pond. No metals could be used in the projects. Groups presented their project orally during class. Each member of the group was assigned the overall project grade achieved for the project. At least two chapters (normally three lectures each) were taught by the question and answer Socratic method.

McClure has experimented with this approach and found that students responded well in the past, but Socratic inquiry requires considerable skill on the part of the teacher. He also found previously that lectures were easier for him to deliver than eliciting responses from the class within a framework of dialogue. In part he hoped to find ways to overcome the difficulties with inquiry teaching.

At least once a week a video tape of a particular manufacturing process was shown and class time was spent discussing the tape. The teacher does not know all the elaborate details of every process shown on the video tapes, so often he intended to answer "I don't know." This response was deliberately chosen to encourage an open discussion format with anticipation that the professor and the class could examine the processes together in detail to experience the concept of team learning. Tapes about metallurgy from the PBS series, "Out of the Fiery Furnace," were used in this class for the first time by McClure.

During the first test of the semester, the students were permitted to use a two page typed crib sheet. Since formulas are normally given on the test, the old style crib sheet full of formulas would be useless. Instead, the students had to organize their note into useful concepts and write them in a coherent fashion. Other computer exercises were assigned as appropriate software was purchased.

The PI's cooperated closely in organizing the course. The actual teaching was performed by McClure with continuous advice, evaluation, and suggestions by Peper and Robinson. Since this teaching method is new to McClure and inter-college cooperation in teaching is not common at UTEP, considerable time was spent in planning and analyzing the course effects. We were also aware of a constant need to reaffirm the collegiality of our professional relationship since the role of evaluation could be seen as annoying, a hindrance, or inhibiting by the course instructor. As a result all participants tried to keep the role of judgment in abeyance while asking each other penetrating questions. We constantly reaffirmed the role of the course instructor as determinative in decisions that affected the events in the classroom.

An education graduate with training in research and evaluation was selected as evaluation coordinator. Her responsibilities were to attend all classes and provide, under Peper's supervision, the PI's with a weekly evaluation of class room effectiveness. The PI's met weekly with the evaluation coordinator and two student assistants assigned to the project weekly to discuss and evaluate progress. A participant evaluation model was supported by the National Science Foundation as described below. We committed ourselves to complete a project evaluation report for both years of the project. This report is of the first year activities and preliminary results which will be used to further refine the project in year two.

One of the most significant aspects of this project is that no increased resources from the University will be needed to continue teaching the course in this non-traditional manner at the conclusion of the proposed grant period. Thus, if the project is successful, the university can adopt it without a reallocation of resources.

Anticipated Results

Five results are anticipated from this project:

1. The curriculum taught in Materials Selection will be better retained by the students than in previous years. This course reaches approximately two thirds of the engineering students at UTEP.

2. Students in the course will be exposed early in their studies to a problem solving and inquiry approach to teaching and learning that they will expect to receive in future courses.

3. With the support of the engineering faculty, other courses will be taught in a non-traditional manner.

4. A dialogue between the College of Education and the College of Engineering will be initiated to share mutual expertise.

5. The results of the project will be communicated in the open literature.

Evaluation Procedures

Project directors and educational researchers (Cohen, 1967; Davé, 1963; Delgado-Gaitan (1993); Dykstra, 1967; Egerton, 1967; Gray, 1960; Rosenshine, 1970; Scriven, 1967, Stake, 1970;

Stevens, 1987) have repeatedly expressed concern about research and evaluation efforts that report summative outcomes with weak ties to process and input variables. An example of this concern is found in Light and Smith's (1970) description and criticism of the National Head Start program evaluation. Their analysis of the problem indicated that excessive emphasis was given to evaluating the total program at the expense of immediate feedback relative to aspects of the program that are working and are not working. Their conclusion was that if evaluators concentrate on the specific functioning of each aspect of a project or program, those which work well will be discovered and then those can be replicated in the continuation of the project or program.

Light and Smith identified three serious flaws in most evaluations: (1) differential effectiveness of the instructional unit, be it teacher in the classroom or equipment in the laboratory; (2) regional differences in student populations, including differences between students in adjacent schools; and (3) individual student variation within each instructional unit. Their conclusion was that components which work need to be identified within a project in order to use the information in future program development.

An operational framework for the proposed genre of evaluation was articulated by Stake and Denny (1969). They make a crucial distinction between educational research and educational evaluation. Research is viewed as being concerned with the discovery and building of principles and with the development of explanatory systems which will enable the effective prediction of educational outcomes. Evaluation shares some of the methodology of research when attention is focused on the attainment of certain performance objectives or a crucial set of comprehensive educational goals. However, evaluation must also include the collection of information about the nature and work of educational programs in order to improve the management decisions that must be made within and about these programs.

Evaluation is different from research in that evaluation gives priority to careful observation and collection of information so that key decision-makers within and external to a project in the initial stages will have adequate information to determine under what if any conditions the project works. Evaluation during initial implementation, therefore, places a premium on internal validity rather than external generalizability under the scientific belief that until internal validity is established, there can be no external validity to either research or evaluation (Kerlinger, 1965).

Stake and Denny (1969) list specific transactions that require feedback to project decision-makers. Early in an evaluation, the proposed statement of goals and objectives must be examined for unique and subtle purposes that the instructor may intend to teach but may not have made explicit. The evaluator probes a selection of alternatives, including and considering priorities, from which the instructor may make choices. These choices must be made initially on he basis of logical connections among the project elements while deferring judgment about the impact of the total program until sufficient reliable replications have been made to establish that the program has an experimental consistency.

Stufflebeam (1977) developed the CIPP (Context, Input, Process and Product) evaluation model to help evaluators relate the conditions of a project to the resources and activities of a project to the outcomes observed. This model was specifically designed with decision-makers as clients in mind. Appendix A is an illustration of this model adapted from Worthen and Sanders (1977).

Another task for evaluators is to provide techniques for assessing instructional materials and classroom instruction to assist instructors as they specify the structure of content and teaching procedures, student performance criteria, the instructional setting as intended, and the kinds of standards that are appropriate for instructional assessment. The task of systematically observing pupil performance within the context of the program is a related responsibility of the evaluator. This creates a further requirement that evaluators produce information about what most students know and on what various ability levels of students are learning. In addition, there is a need for moving evaluation from final assessment of progress toward the diagnostic and prescriptive functions of teaching.

Stake and Denny (1969) also call for the development of formalized procedures for processing information gathered and for drawing inferences from this information. This would include some device for considering the numerous variables involved in decision-making and the registering of confidence in them. Therefore, the main thrust of this evaluation then will be what Scriven (1967) refers to as formative evaluation; namely, providing a continuous flow of information immediately relevant to the decisions that project personnel must make in the management process. From this perspective, elements of the project can be refined or deleted and replaced with more relevant elements if necessary. Summative evaluation will later become more meaningful after careful formative evaluation techniques have been used during project initiation.

Essentially then, evaluation in this project exists (1) to provide McClure with information in a process feedback model format, (2) to provide McClure with student data to be used in making instructional decisions and (3) to report interim and final project effectiveness to the National Science Foundation and to the literature of scholars. The proposed evaluation plan is for reasons explicated above imbedded in the project operation. Distinct components or tasks of evaluation follows; however, this evaluation plan relies on the total project being conducted as planned. Evaluation and project are integral to each other. As proposed, evaluation does not stand alone or separate from the project. Evaluation is part of the project, and the project includes evaluation as a strategy for improvement as well as to satisfy the requirements of external agencies.

Data were organized and collected in eight subsystems that view the evaluation as a total system. The data collection and records systems are identified below.

1.0 Participant Identification Records System

- 1.1 Student data files
- 1.2 Teacher data files
- 1.3 Program staff data file

2.0 Staff Observation System

- 2.1 Planning Activities
- 2.2 Implementation Activities

3.0 Administrative and Narrative Records

4.0 Student Observations

- 4.1 Preliminary Readiness Interviews
- 4.2 Profile of History in Course Related Studies
- 4.3 Self Report of Required and Acquired Competencies
- 4.4 Attitude Surveys of Responses to Course
- 4.5 Comprehension Interviews about Course Structure
- 4.6 Course Examinations of Knowledge and Competencies

5.0 Data Reduction System

- 5.1 Interview Summaries
- 5.2 Course History Profiles
- 5.3 Charts and Tables of Competence Growth
- 5.4 Narrative and Graphic Summaries of Attitudes
- 5.5 Reports of Comprehension of Course Structure
- 5.6 Narrative and Graphic Summaries of Examinations

6.0 Data Analysis System

7.0 Reporting System

- 7.1 Final Evaluation Report
- 7.2 First Year Interim Report
- 7.3 Project Feedback

8.0 Financial Records System

A brief description of each of the evaluation subsystems is presented below. This technique of breaking the functions of evaluation into data collection and reporting systems aids in establishing tasks and placing them in a coordinated schedule.

1.0 An identification and record file will be developed for each member of each participant group in the project. The files will be designed to record biographical data and data identified in subsystems 2.0, 3.0 and 4.0. These records will also serve to facilitate data reduction and analysis through provision of a vehicle for preliminary organization of the data. Biographical variables include but are not limited to student history in science and mathematics courses, length of teacher service, and project staff professional experience.

2.0 A staff observation system will be designed primarily to report to the project staff the degree to which the intended processes or enabling objectives are being met. This system will include narrative records describing activities within each component of the project (e. g. classroom presentations) and checklists based on the intended goals and activities of each component. In-project participant self-report instruments and audio-visual observations will also be used in an attempt to determine instructor perception of project components and standards for success. In addition to these formal aspects of the program, informal teacher-staff conferences will also be monitored by means of logs and check lists maintained by the evaluation staff and instructors. Product or output variables including teacher and student performances in the classroom and laboratories will be systematically monitored. This aspect of the evaluation will center on the frequency of teacher behaviors as reported in daily logs and checklists kept by the participants. Daily logs will be structured to require anecdotal comments on the intended and accomplished goals that the instructor has set for that day. Checklists may specific activities which have been identified by the project staff as desirable.

3.0 Administrative and narrative records are the correspondence and official reports to project funding agencies and university officials concerning the extent to which administrative requirements have been met in the project and the extent to which there was an impact of administrative actions on the ability of the principal investigators to conduct the project as planned.

4.0 Student examinations will be those that are designed and used by the instructor in the conduct of the course.

5.0 Data reduction addresses retrieval and summarization of the data generated by the evaluative process. Two components can be identified within this subsystem; one must deal with the scoring and retrieval of testing data while the other must provide scientific means of summarizing written narrations and checklists and then provide for the entry of these data into the data files. In this second component, coding protocols will be developed for each narrative subsystem and will be used in making a content analysis of each subsystem.

6.0 Data analysis will be complex owing to the formative paradigm that this evaluation will follow in tracking the relationship between and among input, process and output variables. Preliminary analyses will be made to identify the nature of the data being collected. Once this is determined, a final decision will be made concerning the statistical tools to be used. Discriminate analysis has been identified tentatively as one statistical model whose assumptions will be checked against the data. In situations where parametric statistics are not appropriate, non-parametric statistics and measures of central tendency will be used.

7.0 The reporting system specifies when and to whom reports are due. For the evaluator, these are critical points in the project administration since all other evaluation activities must be scheduled to coincide with these mandates. In addition to the reports required by the funding agency (NSF), feedback reports are scheduled to provide project staff with information needed for decisions they must make concerning project development and implementation.

8.0 A crucial concern of evaluation should be the analysis all project component costs through a financial records system. Data collected in this activity are designed to permit cost allocations and cost effectiveness analysis as required by the University of Texas at El Paso and the Funding Agency.

Results of the First Year of Implementation

During the Summer of 1993, the PI's employed an evaluation coordinator to assist in the project evaluation as described above. Two teaching assistants were also employed to assist McClure with the classroom activities. These teaching assistants were funded as an addendum to the original proposal to encourage engineering students to consider teaching as a career. During the summer the course content and teaching strategies were designed and scheduled. Some of the original teaching strategies in the original grant proposal were modified as a result of the lengthy meetings in the summer to provide as much unity between the curriculum, the teaching and student needs of commuter students in a border community. A total of 33 students enrolled in the class. Three dropped the course early in the semester for a variety of reasons, and one student dropped later. Usable records were obtained as unobtrusively as possible on biographical data and other pre-requisite course completion from the university computerized information system. Where those data are possibly sensitive, only records of students who consented to let us use data were used. In parts of this report only 21 records will be reported since they represent the complete set of all collected information. In other cases, including classroom observations, the students who actually attended and completed the class will be reported. In the correlation analysis of effects of student characteristics on course grades, only sixteen complete records were available for the analysis.

Relationships Between Student Background and Course Success

Data in Table I is a descriptive profile of students in the course relative to their SAT scores, prior college grade point average and their average final grades in the course for sixteen students who had all information available. The average grade for this group was 77 with a range of 23 with a minimum of 66 and a high of 89. The verbal mean of 409 was lower than the quantitative mean score of 474. These scores are within a national average range of scores for high graduates. While the Engineering College would prefer that students have a 600 on quantitative scores, these students ranged between 280 and 650 on the quantitative scale. As we shall see from the correlation coefficients below, the lower scores predict adversely on course success. Since this is a relatively small sample, the results are intended as a description of the class and not a generalization to the College of Engineering as a whole.

Table I

Student background and final grades

	Course Grades	SAT Verbal	SAT Quantitative	Grade Point Avg.
Mean	77.06	409.38	474.38	2.64
Standard Error	1.75	17.33	22.71	0.11
Median	78.00	395.00	475.00	2.60
Standard Deviation	6.98	69.33	90.85	0.46
Range	23.00	260.00	370.00	1.47
Minimum	66.00	280.00	280.00	1.94
Maximum	89.00	540.00	650.00	3.41

How did the background data predict course final grades? A correlation coefficient was calculated between course grades and each of the three predictor variables to determine if there was a predictive relationship between the prerequisites and class grades. The following results are all significant at $p < .01$.

Table II

Correlations between SAT Scores, Grade Point Average and Final Grades

	Grade Point Average	SAT Verbal	SAT Quantitative
Final Course Grades	.63	.49	.61
Multiple R .78			

These three background variables in aggregate account for sixty-one percent of the variance in final course grades. Prerequisites for the Materials Sciences courses were adopted to increase the likelihood of students succeeding. For many reasons, including prior education in other countries, some students do not complete all pre-requisites before entering the materials sciences courses. Student course success was also examined by analysis of the final grades of students who had completed all of the course requirements in comparison with students who had completed less than all of the course prerequisites.

Table III

Comparison of Final Grades of Students Who Did and Did not Meet All Prerequisites

Final Grade	Pre-Requisites--YES	Pre-Requisite--NO	TOTAL
A	1	3	4
B	6	4	10
C	4	4	8
D	0	4	4
F	0	4	4
TOTAL	11	19	30

Of the thirty students who remained enrolled in the course, there were four A's, ten B's, eight C's, four D's and four F's. Eleven students completed all of the requirements before the course began and nineteen students were missing one or more of the course requirements. There was no practical difference between the students with A's with respect to meeting prerequisites, but there were no students who had met all course requirements who failed the course. When A, B and C grades are compared for the two groups, one hundred percent of students who had met the pre-requisites received either A, B or C grades while eleven (58%) of nineteen students who had not met the course prerequisites made A, B or C grades. None of the students who met all pre-requisites failed while forty-two percent of students who did not meet all requirements for the course failed. It would appear from these results that students should be strongly counseled to complete all prerequisites before enrolling in this course.

A comparison of the four students who earned a final grade of A versus the four students who earned a final grade of D shows the following:

Group A		Group D	
Average verbal SAT	515.0	Average verbal SAT	310.0
Average math SAT	515.0	Average math SAT	375.0
Average GPA	3.1	Average GPA	2.3
Total quizzes missed	5.0	Total quizzes missed	18.0

The A students as a group scored 205 points higher on the verbal and 140 points higher on the math than the D students. They had an average GPA 0.83 point higher, and they missed only 5 quizzes, as opposed to the 18 the D students missed. On the whole the A group seemed better prepared to enter this engineering course, and their more consistent attendance would indicate their serious intentions to perform well in the class.

The results lead to an inevitable conclusion that background variables predicted final grades for this course quite accurately. This finding was calculated without information concerning individual records ever being reviewed by the course instructor. There was, therefore, no treatment effect of the instructor's prior knowledge of information in biographical records on the students' grades.

Chemistry prerequisite. Another prerequisite was that students complete two chemistry courses. The eleven students who met the chemistry prerequisite for the MET 3203 course earned an A, B, or C. All the D and F students failed to complete the chemistry requirement; in addition, three of the A grades were earned by students who did not take chemistry before enrolling in the course.

Validation of the Curriculum

Material sciences covers a broad spectrum of information and procedures for the manufacture of material. This leaves the introductory course instructor a series of decisions about what is an appropriate scope and sequence of content to be covered in the course. McClure was a professional engineer before becoming a professor. He has a working idea from his practical background that helps him decide on the course content. Nevertheless, it was at first difficult to discern from the course outline and from the initial interviews by Peper and Robinson if McClure held a conceptual model of the course content that he wanted students to hold when the course was complete. In a number of sessions, questions like, "What would you like for students to know if they forgot all else in the course?" and "What should a new engineer know about materials in his first day on the job?" frequently yielded hazy responses. McClure had so much experience in the field that he would respond by saying something like, ". . .if an engineer is well educated he must learn the specific job by doing it." This led to the necessary conclusion by Peper that the course design needed further specificity if students were to leave the course with a good conceptual framework of content of material sciences. Otherwise, it appeared that the course was somewhat disorderly in its presentation. The lessons had no discernible order, nor did they hold together logically.

Askeland (1984), author of the course textbook presented material science as a grid with classifications of materials in one array (metals, ceramics, polymers and composites) and in a second array listed the key applications and properties of each classification of material with a few examples of each in the conceptual grid (p. 2) followed by a discussion of atomic structures of materials and a periodic table of elements similar to those found in chemistry textbooks for his first major subdivision of the textbook. McClure generally followed Askeland's arrangement of topics for his classroom discussions. One of the early activities of the evaluators was to develop a model of materials sciences to test our understanding of the curriculum framework. Figure 1 below is a representation of the general model as presented in the course textbook.

This model is reasonably consistent with curriculum models in other texts and documents. Tapley and Poston (1990) represent material sciences with a line drawing in the form of an

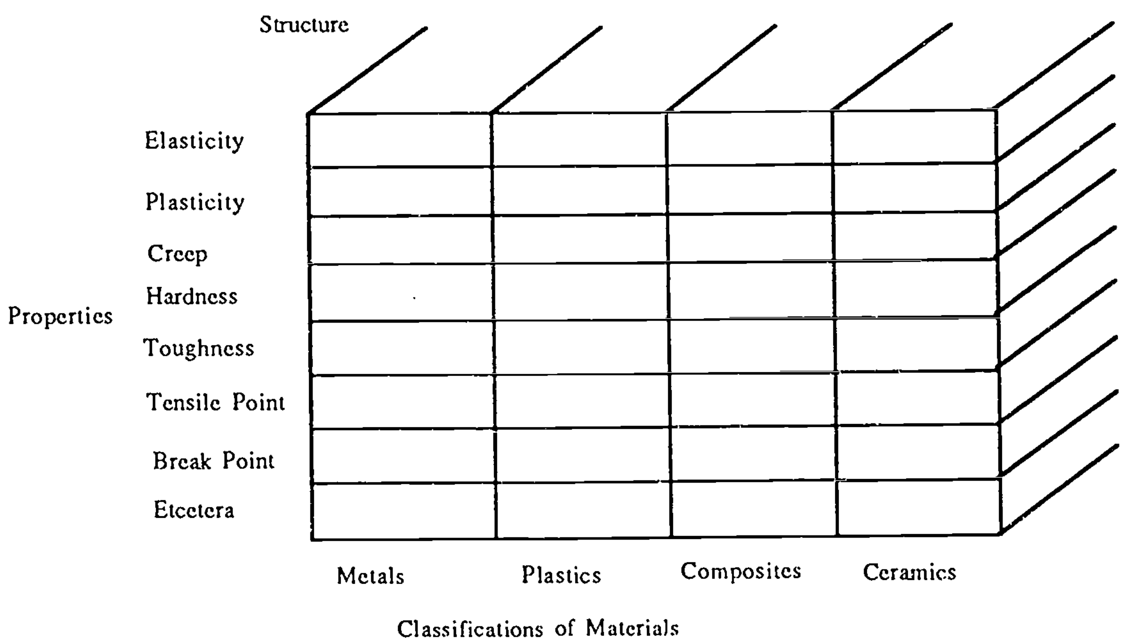

Figure 1. The structure of material science deduced from interviews with the course instructor

organization chart. They classify materials in four slightly different groups (metals, nonmetals, composites, and electronic materials) than Askeland. Tapley and Poston break property listings into physical properties, electrical/magnetic properties, mechanical properties, thermal properties, chemical properties, and fabrication properties. This classification helps the reader understand the purposes and problems encountered in manufacturing materials.

One further classification system of materials sciences is that by Van Vlack (1992). "Materials technology comprises the selection, production, and processing of materials to ensure that they ultimately have the desired shape and specified properties for optimum performance. Materials include plastics, glass, ceramics, metals, and semiconductors; they may be used alone or in combinations... The guiding principles of materials technology are that (1) properties depend directly on the internal structure of the materials, and (2) any desired change in properties requires an appropriate change in the internal structure... The materials engineer must consider further service conditions that can alter the internal structure...The engineer ...has to know whether the chosen materials will perform as required, and whether they will resist failure in service. Key properties include mechanical behavior, electrical and magnetic responses, thermal characteristics, and chemical stability. " Each author presents the material science curriculum structure as (1) classification of materials, (2) properties of materials and (3) the internal atomic structure of materials. The evaluators recommend that in year two, McClure add more precise structure to the curriculum around either one of the accepted structural models of material science curriculum, or that he develop his own and develop all lessons in the curriculum with deliberate presentation of how the lessons flow from the curriculum model. An updated version of the textbook has already been chosen for the Fall 1994 course.

Evaluation and Feedback to Students

A fairly rich group of evaluative activities was used to determine the final grade for each student. These activities included three hour-long tests, weekly professional vocabulary quizzes, a group design project, a comprehensive final exam, and home-work, which consisted of assigned mathematical problems from specific chapters of the text.

Feedback was frequently and regularly given to students. In the case of both the tests and the weekly quizzes, the professor returned graded papers at the following class meeting. In addition, he advised them of the class average on each quiz and test so that a student might figure roughly his standing within the class. Homework was scored by teaching assistants and usually returned within two weeks. The class design project, which was assigned the first week of classes and due the last week, had built-in check points. A written interim report was due several weeks into the semester, and a group meeting with the instructor to give an oral update of its progress was scheduled several weeks before the final report was due.

Course evaluative activities contributed to the final grade in this way:

HOMEWORK	10.00%
FINAL EXAM	11.25%
DESIGN PROJECT	22.50%
QUIZZES	22.50%
TESTS (3)	33.75%
FINAL GRADE	100.00%

To determine the impact of the homework, the impact of the professional vocabulary quizzes, and the impact of the group design project on the final grade, four sets of final grades were recalculated. The first set excludes the homework compon-ent, the second set excludes the quizzes, the third set excludes the project, and the fourth uses adjusted quiz scores. The quiz scores were calculated without the zeros students received for missing quizzes.

Effects of Homework on the Final Grade

Homework contributed a maximum of ten points to the total course grade. Six homework assignments were given, and they were graded by a teaching assistant. Because answers to the problems are in the back of the text, the assignments were just marked that they were completed. The students averaged eight points for the homework, with scores ranging from 3.3 to 10. One view of homework is that it causes students to study more systematically than they would without homework. Another view is that homework, like daily production in a job setting, is a separate albeit important, measure of knowledge or skill attained. Since the examinations, especially the final, are a more direct measure of knowledge and skill attainment, the evaluators were interested in learning whether homework grades differentiated final grade rank in the class. Arguably, if homework contributed in an equally weighted amount to final grades as other classroom measures of performance, eliminating the homework scores would have little or no effect on final grade ranks. The high scoring students would remain high and the lower scoring students would remain low scoring students.

As originally set up by the instructor, homework accounted for 10% of the final grade, and the other four components accounted for 90%. In calculating the final grade rankings without the homework, the final exam accounted for 12.5%, the design project and quiz average were each worth 25%, and the tests were worth 37.5%.

Letter Grade	Final Grade	Final Grade Without Homework
A	4	4
B	10	9
C	8	9
D	4	3
F	3	4
TOTAL	29	29

When the final grades were computed without the homework, eight scores increased, 18 decreased, and three remained the same. The eight gaining students increased a total of 16 points, for an average gain of 2 points each. Eighteen students lost 35 points, for an average loss of 1.94 points. The final letter grade for six students would have changed without the homework grade included in the final average. Results of eliminating homework hypothetically could cause individual letter grades of students to change as indicated above. Originally four students earned A grades with homework counted. Without homework, the number of A grades remains constant at four. B grades decrease to nine, etc. Therefore, eliminating homework as a factor in changing grades would have little effect. One might conclude that the final grade is dependent on homework completed thoroughly, but this analysis failed to show that homework independently contributed to overall grade rank of individuals in the class, but that the homework benefitted one B student and one D student as a reward for effort.

Effects of Professional Vocabulary Quizzes on the Final Grade

Fifteen weekly professional vocabulary quizzes contributed an average of 22.5 points to the total course grade. The quiz was conducted every Monday morning promptly when class began and ended promptly ten minutes later. Tardy students hurt their scores by having less time in which to complete the quiz, and absent students received zeros. The average quiz total for the class was sixty percent. The instructor believes that in a professional field such as engineering one must be able to communicate clearly and effectively with one's peers. He also believes that the quicker students adopt and use the vocabulary of their profession, the quicker they will begin to internalize concepts and think like engineers. Therefore, he emphasized the professional vocabulary in his class discussions, his quizzes, and in the design project report. The evaluators were interested in how the quiz average .mpacted the final grade.

The instructor originally set the quiz average at 22.5% of the final grade. In calculating a new final grade without the quizzes, homework remained at 10%, the final exam became worth 15%, the design project 30%, and the tests 45%.

When the final grades were computed without the vocabulary quizzes, 25 scores improved, two diminished, and two remained the same. Twenty-five students gained 127 points, for an average gain of 5.08 points, while two students lost three points total, an average of 1.5 points. The changes were so large that three students moved to the A range and two to the B range; a total of 11 students had letter grades improve, while 18 remained the same. The following data describe hypothetically what would have happened to the students' grades if the quizzes had not counted and if the other variables had been given new weights as described above.

Letter Grade	Final Grade	Final Grade Without quizzes	Final Grade With Adjusted Quizzes
A	4	7	6
B	10	12	9
C	8	6	10
D	4	1	1
F	3	3	3
TOTAL	29	29	29

Evaluators then considered the effect of the vocabulary quiz average when that average was calculated without the penalizing zeros for students who were absent or late on quiz days. One might speculate that this would be a clearer indicator of how much vocabulary the student actually learned had the student been present and taken quizzes. When the final grades were computed with adjusted vocabulary quiz averages, the scores increased in 26 cases, decreased in one case, and remained the same in two cases. Twenty-six students gained 100 points, for an average of 3.84 points, and one student slipped one point. The changes here were also large enough to effect final letter grades, which included six A's, nine B's, ten C's, one D, and 3 F's. Six students would have letter grades improve, and 23 had no change in the final letter grade had the zero scores not been averaged in the quiz grade average.

Effects of the Group Design Project on the Final Grade

It is a rare engineering company that assigns projects to engineers to work on independently. More often, engineers work in groups. Employers have complained to engineering schools that novice engineers lack necessary skills to work productively and cohesively as a unit. Furthermore, it has been shown that students who work in groups obtain better grades, because they talk about the material, they retain it better. Therefore, the instructor assigned a group design project. Students were permitted to form their own groups of three or four students. McClure specified that each group was to contain engineers from different fields. Each group had at least one civil and one mechanical engineer, plus a chemistry, general science or non-engineering major. Groups were to choose their design topics from a list of three: lobster farm off the coast of San Diego, a mini-Baja car, or a bicycle. The instructor set guidelines for each topic.

The instructor originally set the group design project at 22.5% of the final grade. Without the project, the other components contributed to the final grade in this way: homework, 10%; final exam, 15%; quizzes, 30%; and tests, 45%. Hypothetical removal of the project from the final course grade had a significant impact on the letter grades of the students. Only two received an A, five a B, 13 a C, one a D, and eight failed. Fourteen students' letter grades remained unchanged; but 15 dropped at least one letter grade.

Letter Grade	Final Grade	Final Grade Without Project
A	4	2
B	10	5
C	8	13
D	4	1
F	3	8
TOTAL	29	29

Summary of grade components on final grade

Nine students would never have had a letter grade change with separate removal of grade components from the final average grade; that is, despite the manipulations of the final grade by eliminating one component and having the other components weigh more heavily, those students maintained the same grade. Two of those nine were A students, two B students, two C students, and three F students. Others grades would change by component as described above. It is recommended that the course instructor reconfirm the grading structure in light of this analysis for the coming year. The grading scheme seems to reflect a combination of effort on a daily basis and overall attainment during the course.

Student Responses to the Course

McClure conducted an end of course survey of student responses to the course. Robinson and Peper analyzed the data. In summary, from the forced choice items we learn the following. A majority of the students felt that the weekly vocabulary quizzes were of little or no help. Actual study of memorization and learning techniques by students was for the majority of little or no help as perceived by the class members. Lectures with view graph slides were perceived by seventy two percent of the class as helpful. Ninety percent of the students thought that the videotapes were helpful. Question and answer lectures had fifty percent support as helpful and fifty percent as little or no help as viewed by students. Surprisingly, despite their narrative comments to the contrary, fifty-nine percent of the students thought the group projects were helpful. Fifty-five percent of the students found the semester long design project to be helpful.

This feedback is presented in raw response summary form below.

MET 3203 Evaluations Fall 1993

1. As you know I have tried to do some new things in this course in hopes of improving retention. The best test will be to see what you remember in a few years, but in the meanwhile it would be very helpful to have your impressions of whether these techniques succeeded or not. I will list some of the changes this semester and please circle whether you thought they helped you learn and retain information.

a. Weekly professional vocabulary quizzes

Not Helpful--3	Little Effect--10	Helpful--9
13.6%	45.4%	40.9%

b. Studying memorization techniques (mental pictures, etc.)

Not Helpful--3	Little Effect--12	Helpful--7
13.6%	54.5%	31.8%

c. Lectures largely built around viewgraphs rather than spoken words or text

Not Helpful--1	Little Effect--5	Helpful--16
4.5%	22.7%	72.7%

d. Videotapes to show relevance of materials to "real engineering"

Not Helpful--1	Little Effect--1	Helpful--20
4.5%	4.5%	90.9%

e. Question and answer "lectures" rather than the professor just talking

Helpful--3	Little Effect--8	Helpful--11
13.6%	36.3%	50%

f. Working in groups rather than individually

Not Helpful--2	Little Effect--7	Helpful--13
9%	31.8%	59%

g. A semester design project to show relevance of material

Not Helpful--1	Little Effect--9	Helpful--12
4.5%	40.9%	54.5%

h. Please make specific comments on how the course was conducted:

--"One of the things I didn't like was the teacher-ask-student format, instead of being student-ask-teacher. Probably I feel that way because I learn more when somebody asks a question rather than when somebody is asked . I did like the class explained with projections though."

--"Was alright except that these students, mainly, sophomores & higher are already used to the typical lecture oriented course. For this project to really show how well it works should be conducted with incoming freshman and compared to passed classes. It should also be conducted up until graduation to compare to every other graduate."

--"I think the course was not conducted very successfully due to the fact that I didn't learn much. I think that I wasted my time and the instructor's time. I believe that more emphasize (sic) on capturing the student's interest is requested. I think that the project was not very good because even the TA were not very helpful in helping out, and that prof was not much aware that the project was very time consuming and that this is a beginning course and not a senior design course."

--"The class as a whole was not interested in new teaching techniques. I feel that not enough time was spent on the problems given for homework. Seldom did we ever go over the homework problems, and if we did it was rush; rush. When the major exams are on the homework problems, more time should have been spent on how to work the problems. I feel lost and cheated by not getting this explanation accomplished. Just given the solutions later is not reinforcing learning habits."

--"Enjoyable, tagh (sic) to work in grops (sic), Not everyone put in the same amount of effort."

--"Even though it was hard to imagine how things were usually done in specific chapters, Dr. McClure made it possible for us to observe some of the things by attending labs and visiting factories in Cd. Juarez. I personally didn't participate in class but I enjoyed his class and talking with him about anything."

--"I believe it would have helped if he would give us notes for each chapter."

--"Well, as I saw the course, I think students need more mathematics "lectures". That means, work out more in mathematical (sic) problems because the tests in the course almost cover that."

--"I wish every engineering profess. that " as dedicated to the class as Dr. McClure is."

--"I liked it a lot but I would just like to have worked the problems from each chapter a few days in advance before the exam."

--"Course was conducted O.K. McClure show lots of emphasis on the material."

--"The vocab. quizes (sic) didn't help much. You should show more videotapes, seeing the material more interesting"

--"Even though it worked in our advantage, perhaps covering more topics would be still a good idea."

--"Although I thought the project was a good idea some of the topics had very little to do with materials. I don't feel I would be comfortable choosing materials for a project."

--"It was different but was good and helped me learn."

--"Overall, the course layout is okay. I found that the group project was troublesome. This is because it took up alot of my time and caused me a headache. With the course load students at this level have, a project like this takes up time. Also, when your group does not show up or is unwilling to work it is kind of hard. This is because your butt on the line because it your grade."

--"I personally prefer the old school approach to teaching, If a student is interested and willing to learn any teaching method will be adequate. I would have rather had more essay based questions that tested my knowledge of the concepts and theory. All the problems served only to confuse what exactly was to be learned. I found myself only trying to memorize how to do the specific problems, instead of learning the material. "

--"Because of the changes in teaching the class it seemed as though we were being experimented on. I don't know if this was the actual case, but at times it was disconcerting."

2. *The question and answer format in class is most effective if the class has read the material. I am aware that many people did not regularly read the assigned chapters. If you were one of these people, did you just not have the time, or was the text book genuinely too hard to read?*

--"The book is easy to understand, but since I am not majoring in Metallurgical Engineering I didn't give it the appropriate time."

--"Time management was a problem, but a more detailed syllabus could have helped, because short notice on a chapter change was also a problem."

--"Did not have time to read!!!"

--"I read the chapters as assigned, I made time and divided it according to priority vs. the other classes. If I was behind or failing in a particular class, it got more attention than the ones I was doing OK in."

--"lack of diciple (sic) on their parts"

--"I read most of the chapters but its hard to visualize most of the things there (sic) doing or even more what a washer is or how turbines work."

--"I did not have time"

--"No, all is good, I think the problem is we have too much work in other classes and we only think to pass the class studying a day before test.."

--"For the most part, I didn't have time."

--"No, needed more time because I had to take four other courses besides this one."

--"The text is too vague and really all that helpful, plus jumping around from chapter to chapter didn't help either."

--"Reading it for the first time without any previous introduction by you made difficult to understand."

--"just not have the time."

--"I found the text to be generally boring to read."

--"When I did not read it was usually because of time."

--"not have time."

--"Sometimes I read and sometimes I didn't. However, the book at times was somewhat abstract."

--"Most the time was hard to understand the text book."

3. *On average how many hours per week did you study for the course?*

--3 hours
--Not enough, I studied about 10 hours a week.
--About 3 hours
--Vocabulary required as much as 3 hours the day before the quiz. For major exams, the whole weekend or as much as 8 hours the day before the exam.
--3-5 hours
--2 hours every other day
--5 hours
--3 hours
--I study 1-3 hours a week only.
--About 8 hours

--10 hours
--About 3 hrs.
--I spend about 5-7 hours a week.
--5 hours, I was lost 90% of the time.
--3-4 hours
--3 hours
--Maybe 3 hours / week
--From 5-7 hours / week
--6 hours
--5-6 hours
--about 6 hr. / week
--between 5 and 6 hours

As much as both PI's would like to see more study, it is apparently realistic to expect students to study between three and ten hours per week with a median of about six hours. This amount of study may reflect the fact that students in the course on average work about twenty hours per week and take between two and three other courses. Peper has asked McClure to consider how he would conduct the course if he knew that students would likely only study eight hours per week outside class. One of the realities of a commuter university with working adult students is that expectations of huge amounts of outside class time devoted to homework or study of class materials is apparently unrealistic. Use of class and laboratory time to maximize student learning is essential.

Interview Responses of the Course Instructor

On May 31, 1994 shortly after completion of the first year of this two year study, Peper interviewed McClure to determine his opinions about the project during the first year. The interview results appear below.

Interview
Dr. John McClure
May 31, 1994

At the end of year one, what can we say in a general way about the project?

I can say I've learned a lot. As an experienced college teacher, I am struck by the small amount of time actually spent thinking about the process of education. In this project we, the evaluator, the teaching assistants, and I, would meet weekly and discuss what had happened in class. I received lots of practical insights and honest feedback. Professors get comments from students on their evaluation sheets at the end of the semester, but they are certainly brief and after the fact.

I learned about the project cycle, and also that it is really hard to get students to study. I gave weekly vocabulary quizzes, but while they realized the necessity of being able to speak the professional vocabulary, they didn't spend time memorizing, and consequently did poorly on a significant part of the final grade. They didn't consider the assignments busy work, but they did not put enough time or effort into this class. The amount of time they are willing to spend on a *course is a constraint, and we need to take that into a comprehensible feature.*

Were than any discernible differences in the way you taught this course than the way you have taught the course in the past?

There were three big differences. This year I assigned some group work so that the students would have practical experience working cooperatively with others, much as they would when they are in the working world. I assigned a design project, which was worked on in the groups. And I used the Socratic method, but I did not find it effective for this particular class. The Socratic method requires that students come to class prepared, that is, having read the assigned chapters from the text. These students did not read the assignments. One student commented that he was used to lectures and he had expected lectures in this class. Those are the biggest differences.

Were there any responses of students, in scores or other effects that you notice and think were attributable to the new strategies?

They certainly went about the design project in an enthusiastic way.

But what was the project?

The students divided up into groups of three and chose a project from the list of three I provided. One was to design a bicycle without using metals; one was to design a mini Baja car witnout using steel; the third was to design a lobster farm off the coast of San Diego, which involved pumping up cold salt water to the surface so that lobsters could survive. Most groups picked the bicycle project, but all three projects grabbed their imaginations even though they were complicated. They went about it well.

We are talking about the student responses. You said earlier that the Socratic method didn't quite work well.

I'm not sure that they understood that; some of the new people said that, "Well, I'm in class here, and who's supposed to be telling me about those things?"

Could you pursue that: student expectations for professors and also professors own expectations?

I, and other faculty members, too, feel quite constrained by student expectations of what should go on, not just because of rating at the end of the semester and tenure, but also because if you do anything too differently the students just won't buy into it. These students are reasonably flexible. I didn't have any rebellions on my hands, but they want things in certain ways. Lectures are an efficient way of getting across a certain body of information. Students are used to that, and they are going to be tested on that, so that is one way of teaching.

Regarding the hour tests, I made a bargain that they were going to be very much like the questions in the textbook, which they worked for homework. The students wanted me to spend more time in class working the problems, which I did as a review for the tests, and they wanted me to dwell on a topic at length only if it would be on the test.

So these are the kind of expectations these engineering students had of me. But it is not really what the course is about. And I don't think they really care as much about the solutions to *the problems as about preparing them for the tests. And, of course, to convince them that engineering is more than this. It is estimating and getting a feel of what effects what, developing a good classic nose for where the problem is.*

Those are the things that make a good or bad engineer.

You found that the student expectations were: 1) lecture, 2) work problems in the class, 3) brief the students on what counts for the final grade, 4) grades are very important to them. Bruce Joyce said recently that grades are the currency on a campus.

For whatever it is worth, in the good old days you really didn't have any idea what grade you were going to get in class. You would get tests back and the professor would tell you what the median was and you would get some sense of it that way.

What will you change in the coming year?

I am going to assign several (5 or 6) two to three week projects, instead of one semester-long project. The smaller projects will be more focused, but still classically open-ended. The student TAs and I have already begun planing this portion of the course. Students will be given a problem and told to design a solution, called the project. There is an interplay between analysis and design development. Textbook authors are attempting to relate the engineering problems to real life things.

How do you, a practicing engineer, bring that realism into the classroom?

It is interesting because students really love when you start relating some of your actual life experiences. At the same time, though, I usually joke that they don't want to get me off on war stories. But they do respond very favorably to our stories.

What is the urgency to cover material?

This is my opinion, but it is not just realizing the fact that not much is taught very often and not much is retained. I can cover a lot of chapters, but if the students do not retain the material or internalize it well, I think that it is not useful. If you don't examine the teaching lessons very fairly you may think the goal is to cover the 12 chapters this semester, and if you have done that, then you have done your job. My own opinion is that you have to push and keep a certain pace up, while at the same time making sure the students retain something. I will try to pace the course a little faster next semester so that the students will feel we are moving along and they better get on it.

What was the best experience of this year's effort?

I enjoyed when the students would come to the office and kick around an idea. It was a lot of fun. I especially enjoyed discussing the lobster farm project with those students. Strangely enough, the professor working with the students is fun, but sometimes the professor just doesn't have the time.

What experiences frankly did not work?

I'd have to say the Socratic method just didn't work. I couldn't get them to read the *material in advance, and so that restricted the effectiveness of the method. I am not giving up on the Socratic method. Different classes have different sociologies; the Fall 1994 class will be different from Fall 1993, and the good teacher will figure out what the sociology of the class is and take advantage of that.*

At the end of next year, what effects of this project do you predict?

I'm sure I will be giving them a larger number of projects to do, and I'll take away a greater appreciation of the importance of taking time to focus on the course and lesson objectives. I'm talking about focusing on what I am trying to do when I am teaching, and evaluating how well the lessons were prepared and how well the lessons worked.

Are you a different teacher in any subtle or substantial ways?

I think I am. I pay more attention to details, rather than generally thinking about whether a lesson was effective. I know there is a lot more things going on in the classroom, and that feedback from students comes in different ways.

This cooperative experience with another professor is new for me. What questions do you have of me?

Tell me how to do it right. I think I want as much guidance as I can get. I have been getting good feedback. This evaluation process has been interesting as an aside to the actual purpose of the experiment. But I think we have covered most of everything.

Conclusions and Recommendations

Far more data are available than have been reported in this now lengthy document. As an evaluator, I become more impressed with the need to understand the internal dynamics of classrooms and how they work themselves out than quantifiable results. We have a wealth of baseline objective and subjective data to carry in to the coming year. It is apparent that the expectations of the PI's for students need to be more closely aligned with the expectations that students have of their performance and for the performance of the course instructor. While there is an abundant literature about the culture, anthropology, or sociology of groups, this experience has convinced me that people live out their lives in self constructed realities, and they do not intersect with other the personal worlds of others as much as we might imagine in a mechanistic view of classrooms.

Many of the students in this class will go on to become practicing engineers. Yet, the amount of time that they are able to spend learning their profession at this stage of their development seriously constrains the amount of learning that will occur in this course regardless of how elegant the instructor becomes in his delivery strategies. I am thoroughly convinced that the decision to study is the learner's. I do not know yet how realistic the goal of improving long term retention is given this project model. It is fairly apparent that most of the learning goals of the students are pragmatic. They want to know what to do to pass the next quiz or what effort will suffice to merit a grade. They seem not to grasp the meaning of career learning and the payoff of learning something well the first time as a building block for later more elaborate processing of information.

Without a different kind of direct personal intervention, it appears that only modest gains will be achieved. Perhaps we gain some clues from the enthusiasm that came from the group projects and the support of the students for the videos, the explanatory lectures with visual aids and a seeming strong interest in the real world of engineering. Then, too, the students have perception of an engineering class as lecture and mathematics problems. McClure wants critical thinking and concept formation to develop through Socratic dialogue. The students say, "just show us how to work the problems and give us a quiz on the problems you showed us." Yet they like drafting and design work in groups. Clearly these should provide clues to improving interest and retention. In addition, the course class time could in McClure's estimation be better planned to make the most of the time he has with students. Students' interest in the computer applications are also clues for improved course management.

Finally, it is a strong recommendation that students fulfill all prerequisites prior to admission to this course. If exceptions need to be made for transfer students, a careful analysis should be made either through interview or actual transcript analysis to determine how close their experience at other universities match the prerequisite courses at UTEP. The data are clear. Those students who met the requirements were far more effective in completing the course than those who did not meet all of the prerequisites. It is entirely likely that a class of only those who met the prerequisites would have a quite different sociology than a class made up of well qualified and marginal students.

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