GROUP PROJECTS-BASED FINAL EXAMS

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I. Introduction and Motivation

This contribution describes the efforts made during the last few years at the FAMU-FSU College of Engineering during the teaching of ECH 3264, Transport Phenomena I (Fluid Mechanics) to integrate efficiently the fundamental aspects, practical applications, and laboratory experiments. Among the key factors behind these efforts, one can include, for example, the lack of time to teach everything required in classroom work, the very limited exposure of the students to "real devices" in previous courses, and the need of creating learning environments where students "can make" the connection between fundamental concepts and practical applications.

One important learning tool used in the efforts mentioned above is the group-projects that are, in fact, the final exam of the course. The material selected for these projects is closely related to some of the applications that the student will end up facing at the experiments (in the lab sessions) or in actual practical applications during her/his professional life. The projects start at the very early stages of the course and they are the finishing efforts of the students in the final two-hour closed book exam.

In the sections below, several characteristics of the project-based final exam model will be described and, also, general aspects related to the course will be covered to show an overview of the student effort. Preliminary feedback from the students, the lab instructor, and ABET evaluators seem to indicate that these effort could play an important role in the overall integration of teaching fluid mechanics (to engineering undergraduate students) in a very efficient, relevant, and successful strategy.

II. COURSE MECHANICS

ECH 3264 meets twice a week during two sessions of one hour and fifteen minutes duration for general discussion of material related, mainly to fundamental aspects of fluid mechanics. The course also features an additional class that usually is focused on problem solving techniques and/or general quest ion-and-answer activities among the students or between the students and the instructor.

The course is at the interface between the basic background (mathematics, physics, computation, and some chemistry) and core courses in chemical engineering such as

other transport phenomena courses (heat/mass transport), thermodynamics, and reactor design that will use substantially material learned in ECH 3264. In this particular version of "Transport Phenomena I," students also learn a great deal about responsibility in study habits, independence and self discipline and interaction with other students (partners). Students also learn about professionalism in homework submission, home writing style, and they are introduced to the different learning methodologies. In addition to class discussion, the course includes, class exercises, homeworks, formal reading assignments, midterms, a number of pop-quizzes, and a final exam that is based on the material of all the projects assembled during the term.

In summary, the course will have the following characteristics: (1). The course is taught is a student-centered fashion technique (see below and Arce, 1994) where discussions, group work, etc cover most of the learning activities. (2). The course will have periodic homework assignments that are handed out for detailed work. (3). The quizzes will be of two types, one of them will be centered on the material related to formal reading assignments and the other one will be focused on the material discussed in class. (4). The student class participation is a very important aspect that becomes a differential grading element in the student performance (borderline students could benefit from this). (5). The exams of the course will be of two types. There will be three mid-terms and one final based on the group projects.

The grade distribution usually applied to this course is: Homeworks, 10%; Mid-terms, 15% each; Quizzes, 10%; Final Exam, 35%. Also, a folder is required to be kept during the course. This folder becomes another differential grading element in the student performance. Students are advised that, although homework sets and project reports are items that required substantial amount of time, they are "low risk stocks" in the point accumulation system. Quizzes and class participation are probably the next items in the low risk list. A failing quiz would most likely indicate that the student is not making a serious attempt to learn the material and, therefore, her/his self discipline is not particularly useful.

III. Group-Projects and the Final Exam

One of the first activities in the selection of the topics for the projects is to make sure that the material complements the list of items to be covered in the classroom work (see Table 1: Heading of Course Topics). Also, it is important that project topics are selected in order to cover the description of the devices used in the laboratory experiments during the semester after ECH 3264 is finished. In addition the number of projects must be "tuned up" for the number of groups that are possible to assembly during the particular term. Usually, only groups of three students are allowed. Sometimes, and because of the enrollment limitations some groups of two students are also permitted but these groups are strongly discouraged otherwise due to reasons that will be discussed later on.

Table 2 lists the different topics that are typically suggested for the ECH 3264 Course at the College of Engineering at Florida A&M and Florida State University, Tallahassee, Florida. The table also shows the suggested pointers that are included as part of the

material given to the groups. These items can be viewed as the "seed points" that students can use to formulate their own version of the project outline in collaboration with the instructor of the course.

III.1 Group Member Selection and Choice of Project Topics

One of the first activities that students are involved with is the selection of the member of their groups. This is a very important step for the successful outcome of the project. Students are briefly reminded of the importance of step and that, in a way, this selection process is very similar to buy a used car. They must determine that this car will take them from point "A" to point "B" and that any braking of the car in a middle of the road would cause problems. By the same token, students that do not last until the end would hurt the project dynamics. It is interesting to see that reliability and efficiency in working habits (in students) have replaced, in the past, "friendship" after a project (in a previous course) did not turned as they expected! Also, possibility of losing group members, after the project has started, make the number of three as an ideal one.

The next important activity for the students is the choice of the topic of the project. Usually, the number of topics is the same as the number of groups. Then, students must engage in a negotiating process. Sometimes, they meet in an "open Forum" with or with the instructor and they discuss the pro and cons (from their perspective) to take over one or other topic. In some occasions, students had had some experience or exposure to some topics and they can make the argument that this aspect will be beneficial for everyone in the class. The reader must recall that the material of all the projects are included in the final. After a series of meetings with discussions almost everybody is able to choose a topic with one they can live with.

III.2 Activities and Schedule

Once selection of group members and choice of project topics have been completed, the group is ready to initiate formal activities in their assignments. All groups have a period of time where they have the opportunity to discuss with the instructor the "seed suggestions" for the outline. Every activity from now on has a deadline (see Table 3, "Schedule") and if the group misses one of these deadlines is not allowed to take the final although they may stay in the course. This, of course, introduces a very important accountability factor in the group member. If they fail to meet one of these deadlines, there is a very important price to pay. This aspect is introduced to promote individual and group responsibility as well as to foster early involvement in the development of the project material.

Students are provided with guidelines regarding the fact that these projects are of a "educational nature" and not necessarily of a "research nature" and, therefore, the material can be developed from textbooks, journal articles, commercial catalogs, and in consultation with lab instructors. The commercial catalogs play an important role in the selection procedures of, for example, flowmeters, pumps, valves, etc. Many groups are

able to obtain catalogs and reference material in a very similar way to that when they eventually become professional engineers.

During the earlier stages of some of the projects students are warned that the material for the project may be somewhat advanced for their level. This debalance, however, will be modified as time passed. During this time students may want to focus their activities on the descriptive aspects of the project. Students are strongly advised to keep a folder or notebook with notes and material analyzed so that this can be used effectively in the final writing of the report of the project.

Finally, students are encouraged to meet as a class and discuss as many times as they feel is necessary as to review and update material development. For these meetings, students may or may not invite the instructor of the course. In the past versions, many students have taken the advantage of meeting as a class to discuss the evolution of their projects.

The final exam will have a project presentation by the group, a written report, and a two-hour, closed book exam. The project presentation will be graded by the whole class (including the instructor as one more evaluator) following a format similar to the one used by the AIChE student competitions. The relative weight of this evaluation is 25% of the grade of the final. The project report (to be evaluated by the instructor) will have another 25% of the grade of the final. The two-hour test on the project material will have a total of 50% relative weight of the grade of the final exam.

IV. Feedback from Students and Lab Instructors

The methodology has been evaluated indirectly by informal interviews of a number of students that have taken the course. There is a strong agreement that the methodology provides (for many for the first time) a presentation of results and their defense in front of peers and, also, for many it is the first time that they must document, in a logical way, findings and analysis about a given project. From the point of view of active involvement, many students mentioned that the project has forced them to think about how to put a core of knowledge together without the spoon feeding from the instructor. It is important to point out that this comment is useful along the line on which the course is being taught, the Colloquial Approach. This methodology requires strong personal involvement and initiative.

Also, interviews with the lab instructor that has been exposed to both project and without project versions have been conducted. These indicate that students are much more focused and more active when they have studied with the project version of the course. In addition, ABET evaluators have welcome the methodology since the approach put students immediately in a "real world" type of problems and they have, obviously, an open-ended solution.

V. Concluding Remarks

In this contribution, we have introduced a teaching methodology for fluid mechanics in Chemical Engineering courses that uses group-projects as the final exam. The approach uses the fundamental concepts learned in classroom work and connect them with applications and devices some of them related to the lab sessions. One of the key differences with other courses with projects is that students are responsible for the material of all the projects in the class and that an evaluation of the presentation is made by students. We believe that the approach offers a great tool to integrate fundamentals, applications and experimental devices in a very active learning environment.

References:

Arce, P., "The Colloquial Approach: An Active Learning Technique", Jr. of Sci. Educ. and Technology, 3 (3), 145, 1994.

Appendix

The Colloquial Approach is an active learning technique that does not use lectures as the way to convey information and new concepts. Instead, questions and class discussion dominates the way to introduce the new material based on the previous background and every day ideas and experiences. The student is put in a very active learning environment, where he/she must participate actively to learn the concepts, check answers, and make progress. The technique challenges the students to be pro-active, organized, and to up-date the material every week before the topic is introduced.

Table 1: Headings of Instructional Units

1. Vectors and Function Analysis. 2. Fundamentals and Description of Forces. 3. Forces and Relationships with Work and Energy. 4. Inclined Planes. 5. Introduction to Continuum Mechanics and Conservation of Mass. 6. Conservation of Total Momentum and Hydrostatics. 7. Inviscid and Viscous Flow Theory.

Table 2: Projects Title and Pointers

1. Friction Factors: Application to Piping Calculation

- Identification of friction factors: reason/s why are they needed.
- Basic mathematical formulation: equations, graphs, etc.
- Basic elements of piping calculation: uses, materials, protection, etc.
- Classical selections in the calculation of length, size, etc., in a giving piping application (i.e., given the flow rate of the system, calculate the diameter of the piping system including losses for values, elbows, etc.).
- Identification of Computer software available for piping calculation. Basic information required to run the computer program.
- Examples of applications.

2. Turbulence: Ideas, Modeling, Calculations

- Basic idea of turbulence in hydrodynamics.
- Difference with respect laminar flows.
- Models used to describe turbulent flows: basic ideas and equations.
- Examples where turbulence is beneficial in chemical engineering applications. Application of one of the models to derive velocity profiles.

3. Boundary Layer Flows: Fundamentals, Models, Solutions.

- Idea of a boundary layer model for fluid mechanics applications.
- Relevance of the boundary layer model in viscous flow theory.
- Differential approach: Prandtl model.
- Integral approach: von Karman's Model.
- Determination of velocity profiles and boundary layer thickness. Comparisons.

- Applications to chemical engineering problems.

4. Non-Dimensional Analysis in Hydrodynamics
- Ideas, concepts, advantages and disadvantages of non-linear analysis.
- Principle of dimensional homogeneity.
- The Buckingham Pi Theorem (i.e., B-P).
- Applications of the B-P theorem.
- The Rayleigh Method: Comparison with the B-P theorem method.

5. Flow meters: Fundamentals, Types, Measurements
- Basic concept of a flow meter.
- Types of flow meters: advantages/disadvantages.
- Basic design equations and equations to compute pressure differences, point velocity, etc.
- Important parameters in the design/selection of flow meters.
- Commercial types of flow meters available for applications.
- Description and use of flow meters available at the chemical engineering lab.
- Losses caused by flow meters.

6. The Bemouille equation for Energy Conservation
- History of the Equation.
- Fundamental assumptions and derivation.
- Application of the equation to a variety of fluid flow problems.

Table 3: Schedule of Activities

1. February 1, 1999. All groups must have finished the discussion with the instructor regarding the scope of the project, potential literature, material to be covered and instructions to formulate the project outline.
2. March 1, 1999. Detailed outline due date. All groups must submit to the instructor and to class a detailed outline of project. Literature and some preliminary work is highly recommended. Presentation (to the class) with or without the instructor is highly recommended.
3. March 31, 1999. Mid-term report due date. No regular class will be held this week- however, the instructor will be available for consultation for presentation of results on Monday March 29, 1999 at regular class time. Preliminary report must be submitted to class and to the instructor. This report must show substantial progress (but not necessary finished work). A class meeting to explain progress, problems, ideas to finish, etc. is required. It's beneficial that the instructor be present. This meeting must be on regular class schedule, but a longer time may be needed.
4. April 26, 1999. Prelim-Final. An almost final version of the report must be made available to the class, All fundamental aspects must be finished and clearly stated. Pointers to finish the project must be stated. Check the progress with the outline of point 2 (above).
5. Last Friday of classes (tentative): Final presentation and report submission to instructor and to the class. A presentation (about 20 min. per group) will be evaluated by instructor and class.
6. Final exam: A two-hour, written, closed book and notes exam will be taken and it will be focused on the material covered by all the projects. This exam amounts for 501/o of the final exam grade.

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ROLE OF THE HONOR PROGRAM IN THE ATTRACTION & RETENTION OF BRIGHTEST AND THE BEST CHEME STUDENTS

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I. Introduction

The Department of Chemical Engineering at the FAMU-FSU College of Engineering has introduced some years ago a very active "Honors in The Major" option that has been very successful in attracting some of the brightest and most capable students in the program. The option has been designed to introduce qualified students to research environments at early stages of their careers. The program is based on research projects that are tailored to fit the time frame of the students and to give them a very meaningful experience during this period. The topics of the projects have ranged from purely experimental studies to highly sophisticated theoretical problems in a variety of chemical engineering applications.

The option has become a popular one among the most advanced students in the program and they feel that the opportunity of being involved in research, at very early stages of their careers, is very useful to complement the academic activities in the regular courses. Also, many of them realizes that being an "honor student" in the program gives them the chance of learning about a given subject in depth. This (for many) has a very positive outcome in job interviews during which they are able to discuss a topic from a very different angle compared to the one possible for the more regular students. For others, a research opportunity brings the possibility of exploring whether or not the graduate school will, indeed, be a viable option for them.

This contribution will discuss some of the characteristics and requirement of the program and will give some illustrations about the topics and accomplishments achieved in the last few years.

II. Requirements, Characteristics, and Obligations

Although students can be involved in research projects at any time, the application for the "Honors in the Major" option is not required until they reach junior status in the Chemical Engineering program. Several reasons are associated with this guideline but

perhaps two key ideas are: (1) Students must have completed a substantial number of courses in the curriculum so that the research project can offer a meaningful experience; (2) Students, at the junior level, are eligible for the senior elective courses and since the "Honor Project" can substitute these requirements they have a choice. In order to be considered for the "Honors in the Major" option, the students must have achieved a minimum overall GPA of 3.2/4 at the time of their junior year. Students with a GPA that is below this minimum are strongly encouraged to follow the regular option of taking courses (i.e., electives) to meet graduation requirements.

The application procedure has varied from the earlier stages until now. One of the options involves the filling out of a form and the writing of an essay. This essay must include reasons why the student is interested in the "Honors in the Major" option, what would be the role of research in the future plan of the student, and how the research aspects would enhance the education of the student. The application is then reviewed by the "Director of Honor Program" at the department and usually student and director meet to discuss the program. Afterwards, the student must interview a number of faculties that have indicated their interest in directing students in Honors Projects. The student must summarizes the interview and propose a list with the top three professor choices and the project of their preference. Finally, student and director meet and the final decision about project assignation is made.

The director, after analyzing the documentation submitted by the student and discussing with the candidate the application material may suggest that this re-evaluate the idea about the "Honors Project". Sometimes, the student does not meet the profile required to be a successful research oriented individual.

Once the project has been assigned, the director and the student work out a schedule of activities. The director must understand that this student is not to be used to "support" graduate student activities and/or to perform “minor” activities in the laboratory. Our experience has indicated that a direct supervision of the honor student in one relevant project is one of the most fruitful aspects of the Honor in Major Project.

The student must submit to the Honor and Scholar Office of the University a "Prospectus" with a general idea about the research to be conducted. This prospectus should not be a "contract" written by the director with the student activities but rather a “proposal” from the student elaborated with the help of the director. This is the reason by which students are encouraged to start their project during the summer previous to the Fall Term when they are officially admitted to the program. The prospectus also requires the selection of two additional professors to serve as committee members. Their role is similar to that of a thesis committee in a Master or Ph.D. program. The student must submit to this committee a written mid-term report with preliminary results. Many times is highly suggested that this report be "defended" in an oral presentation.

Finally, the student must write and defend a thesis at the end of the term selected f or the honor program which can not be less than two full semesters. For many projects, it is

highly advisable to work during three semesters. This option typically involves the summer session after the senior year have been completed.

Table 1: Slected Projects and Advisors

1. Sharon Sauer, "Solute Transport under the Influence of Two Ortoghonal Electrical Fields in Laminar Flow Regime: An Area Averaging Approach" (Dr. Arce, NSF Scholar at Rice University).

2. Ken Bowser, "The Design of Controllers for Severely Non-Linear Systems" (Dr. S. Palanki).

3. T. Montgomery, "Convective-Diffusive Transport and Reaction in Composite Domains" (Dr. B. Locke).

4. G. Jarvier, "Regularization Techniques for Solving Fredholm Integral Equations of the Fist Kind" (Dr. Chella)

5. Chelsey Phyllips, "Electrosettling of Sewage Water: An Experimental Study" (Dr. P Arce and Mr. Finney)

6. Dumas, K. "Aerosol Transport Mechanisms in Lungs" (Dr. M.H.Peters).

7. J. Norman, "Effect of Particle Roughness and of Non-Newtonian Fluids on Sedimentation Processes" (Dr. P. Arce and Dr. D. Loper).

III. Accomplishments

I have been the Director of the Honors in the Major at the Chemical Engineering Department from 1994 to 1998. During this time, the program has reached an all time high in student enrollment having an average of about eight to ten students in residence working with different professors. The students have been involved in both theoretical as well as experimental projects (see Table 1). Several of these students have participated in presentations at the Annual Meeting of the AIChE, regional meetings of the American Chemical Society, Annual meeting of the Fluid Dynamics Division of the American Physical Society and international meetings such as the "II Encuentro Latinoamericano de Engenieria Quimica" held in Antofagasta, Chile, among other meetings. Many of the students have been given awards for excellence in their presentations.

Also, several of students have been able to publish articles in peer review journals such as the I&E Chem. Res., The Proceedings of the International Congress of Rheology, and others. The majority of the students have continued their careers in the graduate school, and they can be found at the Department of Chemical Engineering at Rice University, Northwestern University, University of Texas-Austin, and the University of Florida, among others, where they are pursuing their doctoral degrees. Few have been able to obtain prestigious fellowships such as the NSF, and other university fellowships. Others have received excellent job offers that have a salary level much higher than other offers given to non-honors students in the program. Some of the companies that hired honors students have been keen in hiring new honors students, some even from the same group.

IV. Concluding Remarks

The Honors in the Major Program at the Department of Chemical Engineering has been successful in retaining some of the best and most promising students in the program. Many have indicated that one of the reasons that they stated in the program is the availability of the Honors in Major Program. This, indeed, has been very effective in producing high quality undergraduate that now are very successful either in graduate school or in the professional life. One of the key factors in the success of the program has been the careful selection of the matching between the student and the director and the commitment and dedication of the faculty involved in the direction of these students. In addition to this attributes, the development of a respectful environment and caring attitude towards the students involve in research have promoted a positive effect in attracting new candidates for the program.

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