

DEVELOPMENT, IMPLEMENTATION, AND ASSESSMENT OF HIGH PERFORMANCE LEARNING ENVIRONMENTS

Sharon G. Sauer and Pedro E. Arce

I. INTRODUCTION

ABET EC2000 is looking for positive changes in the engineering curriculum and the teaching process. Instructors should depart from old-fashioned, non-effective methodologies (from the learning point of view), and from non-motivating approaches such the ‘solo performance’ with the back of the instructor to the students and/or with the instructor writing equations, on overhead transparencies, so small that the students seated in the back can not see them. Ineffective engineering instructional methodologies have been the reasons for which, in many cases, very good candidates for the engineering profession have abandoned the course work to go to other disciplines. Computer Sciences, English, Communications, and Psychology have been the beneficiary of these “transfers.”

ABET EC2000 reviewers want to see greater dynamics in the engineering learning environment with increased student participation. In fact, these environments must have characteristics much more close to that of the practical aspects of the profession such as teamwork abilities, excellent communications skills, and motivation for life-long learning. (Please see Table 1 below for a Summary of ABET aspects involved in the approach). One of the most overlooked aspects in the training of engineering students is teamwork within synergetic collaborative learning approaches that a student-centered environment can develop. Teamwork, though, is not easy to teach, is time consuming to implement and very difficult to evaluate and, yet, crucial for the completion of a well-rounded engineer. Training students in teamwork requires a completely new type of class (and beyond) environment with totally different activities and instructor teaching practices: one that is more closely positioned to a “sport coach” with the ability to change the learning pace, promote students’ activities, and with a strong command of the psychology of learning. Teamwork also requires the development of new student training methods and new assessment methodologies.

In this contribution, the authors will discuss several aspects related to teamwork within the “group (team) based final exams” approach or “high performance learning environments” for engineering majors (See Arce and Schreiber, 2003). A focal point of the contribution will be on the assessment required in this type of approach. An introduction to the subject may be found in Arce (1999) with other additional characteristics included as well. The subject related to the new type of “professional of instruction” is included in the article by Linda Creighton (*Prism*, April 2001) on Arce’s coach model of instruction; please see, also, Arce and Arce-Trigatti (2000).

II. BACKGROUND AND RATIONALE

Participation in teams is known in certain aspects of chemical engineering majors. For example, the Unit Operation Laboratory (UOL) is one key place where students are heavily exposed to work that strongly depends on teams and, consequently, the assessment must be performed in a fashion that captures this mode of instruction. The instructor, here, needs to be skilled in assessing teamwork and in avoiding to let students pass the course without reaching minimum standards. Therefore, the assessment of teamwork has been around the curriculum for a number of years. However, because of the lack of integrating between the UOL and the “classroom instruction,” the situation in other non-lab oriented courses is not the same. In fact, there is a misconception (in many faculty) that team-based instruction is not of the “same quality” as individual-oriented instruction when it comes to assessment. In this contribution, we will describe some aspects that we believe are helpful to achieve a high level of student involvement in team-oriented environments with a proper assessment of performance. Descriptions related to these aspects are included below.

Why Projects as Final Exams? The use of projects as an enhancement of class instruction, although not widely spread across the curriculum, is known to engineering instructors. These projects, in general, are targeted for the instruction of certain techniques that are either too involved or too difficult to introduce as a regular topic during the course. However, the assessment of these projects is separated from the final exam and they usually amount for a small percentage of the total grade. One possible exception is the case of Senior Design Courses and the UOL. A few years ago, we began experimenting with the use of group-based final exams as a way to radically change the student view of the exam, to increase student responsibility in the decision-making process, to inject a more ‘practical view’ of the training, and to tie the instruction to the lab experiments. The preliminary evaluation was very promising (see Arce, 1999) and a more formal structure of the approach was implemented (see the section below).

Concerns raised by ‘traditional’ instructors on the use of projects as final exams include the assessment part of the project itself. According to these traditional instructors, students with low individual performance will make the grade just because the ‘active’ ones will carry them through the process. These concerns usually come from both the traditional ways of teaching and assessment and from instructors not familiar with the training of students within a team environment (Smith, 2000). The instructor believes that only *individual* tested material is good to become an engineer. However, just because students work together does not necessarily mean that individual students will not achieve high performance and that their work cannot be assessed. As previously mentioned, teamwork requires a totally different learning and assessment strategy. Interestingly enough, one of the first requirements in the professional work force is to work together well in order to achieve meaningful objectives!

Therefore, why is it not possible to use the final exams (one of the most important aspects

of the course) to train students in teamwork, and to learn and to assess how well students have learned the material? It will require few changes. For example: Can we develop environments where every student can achieve a high level of self-confidence? Can we train them in effectively work in teams? Can we assess if these objectives have been achieved? Now the objectives have changed and new learning strategies and assessment tools must be designed and implemented. In addition to this *let-motive*, other aspects come to play a role in the design and implementation of the environment. Can we use this opportunity to enhance the motivation by connecting fundamentals with practical (i.e., experimental) aspects? Can we encourage students to explore different ways to learn about a particular topic? Can we invite the students to participate in the selection of a device that is needed in a practical application? Finally, can we assess how well the students mastered the material both individually and as a team? These are the guideline principles that we have used to develop and implement the group (team) projects based final exams. A brief description of the various aspects of such an approach is subsequently included.

How Does It Work?: The heart of the “Group (team) Based-Final Exams’ is the project that a team of students works on from the first day of classes. Figure 1 summarizes the different elements of this high performance and active learning environment. In addition to the *team projects*, Figure 1 shows three additional elements of the methodology that supports the learning platform: one is focused on the *class activities*, the second on the *communication development unit*, the third on the *activity related to the lab* and, finally, the fourth element is centered on the *interactions with providers or dealers* of instrumentation and/or devices.

The elements of the approach work interactively to motivate and focus the students, to promote thinking and develop efficient communication skills, to check ideas with hands-on demonstrations and to learn how to interact with real dealers or providers of chemical engineering equipment. Furthermore, the environment helps the student to connect the concepts with experiments that they must perform in the lab the following semester. Alternatively, the lab becomes what it always should be: The most powerful active learning tool. The methodology gradually and sequentially prepares the students for the work force.

The team of students start working the first week of classes with a number of activities related to partner selection, analysis of topics, and introduction to the various aspects of the team functions (see Figure 1). Many of these items are discussed during an extra recitation session that is usually on Monday evening from 7:30 to 9:00 p.m., but it frequently goes until every item in the agenda is fully covered. The Lab Instructor is usually present during these sessions and is available for comments and suggestions related to experiments. Topics for the projects are closely coordinated with the lab needs and minimum requirements are also established. This makes the methodology a very efficient way of integrating fundamentals with applications. Projects are in equal number to groups and students must negotiate the assignation of the topics. Very brief guidelines are provided and students are encouraged to find procedures and additional guidelines that

will facilitate the assignments (see Arce, 1999). During the semester, the students work on aspects that are usually divided in two categories (see Table 2). The first category requires a working knowledge mastered at the “*technician level*” and the second, at the “*engineering level*.” The former comes at the earliest stages of the work and the latter, at the stages when the students have advanced with the learning of fundamentals.

The formal assessment of the projects comes at the end with a variety of tools. Students must prepared a folder including supporting documents, a short report of about fifteen pages, and they must give a presentation to the class that is evaluated by peers. In addition, they have a two-hour final closed book exam on the material on all the projects. This promotes quite a bit of interaction and communications on the development and sharing of material during the semester. During one of the academic year, Dr. Loren Schrieber (UOL Director at the COE-FSU) proposed a poster session as an assessment tool instead of a formal presentation. Immediately, we transformed this idea in a “poster competition” similar to those of high school science fairs. Students must prepare a poster board, have their folders and a draft of the report ready for consultation, and present an experimental illustration or demonstration of the central topic of the project. Two “external judges” that receive a brief guideline for assessment evaluate the competition but are encouraged to use their own tools after mutual agreement. Usually, instructors from other departments and/or departments of a different university play the role of judges. The event takes place in the atrium of our COE building at FSU. In addition to grading the projects, the judges also select a winner, i.e. a ‘top project,’ that receives a bonus in the final grade.

III. ASSESSMENT OF THE APPROACH

The methodology was evaluated by using three different assessment tools. The first and most extensive assessment was by discussions with the judges after they conducted evaluations with students. The second one was by doing informal interviews with students after they finished the poster competition and, then, after they finished the course. In one case, a questionnaire was handed to the student with questions related to the different aspects of the course. This was the third tool used for gathering data on performance. The most detailed and most excruciating one has been the discussions with and feedback from the evaluators. This usually takes place immediately after the judges have finished their interviews with the students for evaluating the poster competition.

Feedback from the judges has strongly supported this type of approach. The judges have detected a much higher motivation and knowledge level in the students engaged in this approach than the one usually observed in traditional classroom instruction. They have noted that the students are self confident in what they need to know and they handle questions well. In addition, they mentioned that the skill level during the presentations and discussions was extremely high. During interviews, students have expressed their overall satisfaction on the methodology in that interaction, teamwork, and interchange of information as well as managerial aspects could be better learned within the environment.

The responses to the questionnaire indicated that the methodology is demanding in time and effort and some of the students might not be ready (in our college) to invest such time as other universities with a strong tradition of quality engineering instruction. One such case observed by author is Purdue University. Finally, Lab Instructors noted a substantial level of readiness in students that participated in the methodology, when they perform lab experiments, compared to the ones that did not take part in the approach.

In conclusion, the approach is robust in promoting student motivation, enhancing student learning, and helping in retaining a higher level of knowledge in the students compared with traditional approaches. Furthermore, the environment is very effective to implement a number of ABET criteria in a meaningful way from the student point of view. More work is needed to educate the students on the investment in time and effort required to be a solid engineer in training. Aspects related to these points as well as more quantitative evaluation are currently being implemented in present efforts.

Acknowledgements: The authors wish to thank the support and encouragement received from the Unit Operations Laboratory (UOL) Director at FSU, Dr. L. Schreiber. His feedback, willingness to help students, and overall enthusiasm for the methodology have been highly beneficial for the improvement of the approach. Mr. Richard Chrisler (FSU-UOL Coordinator) is also thanked for his time and help dedicated to the students needing assistance with experiments. Judges that have taken part in the evaluation of the “poster competition” include Dr. M. Alfano (INTEC, Argentina), Dr. E. Kalu (ChE, FSU), Dr. C. Luongo (ME, COE and Magnet Lab-FSU), Dr. L. Schreiber (ChE), Dr. D. Wesson (ChE, FSU), Dr. D. Miller (ChE, RHIT), and Dr. A. Serbezov (ChE, RHIT). Their feedback has been very helpful in achieving better results. Student feedback and participation have been invaluable.

References

1. Arce, P. “Group Projects-Based Final Exams,” Proceeding of the Annual Meeting of the ASEE, 1999.
2. Arce, P. and P. Arce-Trigatti, “Parallel between Team Sport Coaching Techniques and Engineering Instructions,” Proceeding of the Annual Meeting of the ASEE, 2000.
3. Arce, P., and L. B. Schreiber, “High Performance Learning Environment or Hi-Pele,” (Pre-print, 2003).
4. Creighton, L., “Kicking Old Habits” *Prism Magazine*, April Issue, 33 (2001).
5. Smith, K., “*Project Management and Teamwork*,” McGraw Hill BEST, N.Y. (2000).

Table 1: Summary of ABET Criteria Involved in the Approach

- | | |
|----|--|
| a) | the nature of the problem/project requires the application of mathematics, science, and engineering knowledge. |
| b) | analysis and interpretation of data (depending on assignment) |
| c) | design – the project is a “design” project |
| d) | teamwork but not necessarily “multi-disciplinary” |

- e) requires the identification, formulations and solution of an engineering problem
 - f) professional and ethical responsibilities are incorporated through the grade sharing – everyone is responsible and need to hold each other accountable.
 - g) Communication Skills:
 - Poster Presentation with external evaluators, including Q&A
 - Written Report
 - Peers – weekly (or more frequent) meetings, including taking minutes, using agendas.
 - Vendors, companies using the type of systems (local power plant)
 - i) exposes the students for the need for life-long learning in that each engineering project they will undertake, they do not have the necessary information given to them but are required to find that out and learn new material with little assistance in order to solve the problem
 - k) requires use of presentation software such as PowerPoint to prepare the poster presentation; flow charts and other equipment diagrams are needed – software usage can certainly be incorporated. Aspen, Hysys or other simulators can be incorporated.
-

Table 2: Activities Level for Teamwork

a- Practical (i.e., What a Technician Needs to Know to Run the Experiment)

1. Device Characterization and Technical Description
2. Identification of Variables (i.e., pressure, velocity, viscosity, etc) Associated with the Device Measurements. Role in a Chemical Plant. Illustrative Examples.
3. Experimental Procedure used in the Measurements
4. Commercial and Lab Devices: Types and Selection Criteria
5. Suppliers

b- Engineering (i.e., What an Engineer Should Know to Understand the Experiment)

6. Engineering Equations used to Perform Measurements with the Device: Derivation from Fundamentals Principles and Application
 7. Worked out Examples of Problems that Involved the Variables (see 2) and the Device
 8. Identification of Physical Situations that can be described or Understood using the Know-How gained in this Project.
 9. Produce a Class Demonstration to Show the Basic Aspects of Your Project.
-

Key Words:

Team work; team assessment; ABET Criteria; Final Exams; Collaborative work; UOL; Active learning.

Contact information about the authors:

A- Dr. Sharon Sauer, Chemical Engineering, Rose-Hulman Institute of Technology, Terre-Haute, IN; 5500 Wabash Avenue, CM 53, Terre Haute, IN 47803, E-mail: Sharon.G.Sauer@rose-hulman.edu Voice: 812-877-8527, Fax: 812-877-8992.

B- Dr. Pedro Arce, Chemical Engineering, Tennessee Technological University, Box 5013, Prescott Hall Room 214, Cookeville, TN 38505. Email: parce@tntech.edu. Voice: 931-372-3189, Fax: 931-372-6352.

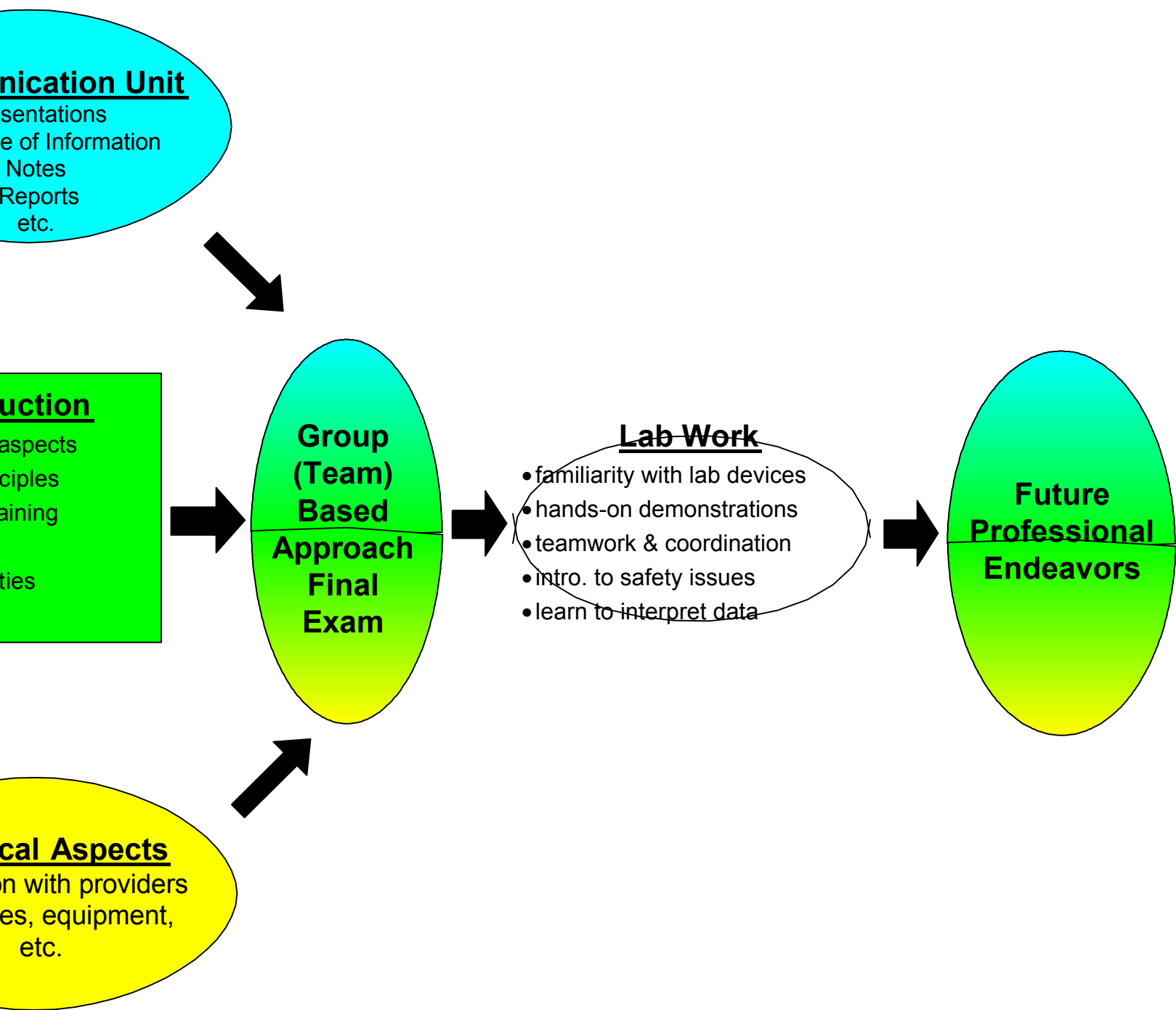


Figure 1: A Typical Model in HI-PELE.