International Integrated Experience in Engineering Education at the University of Oklahoma

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Abstract

Large numbers of international students have been educated in the United States over the past decades. In engineering this scenario is no different, to the extent that foreign students constitute the majority of the graduate student population. The challenges of the programs offered by these Universities are (i) to meet the expectations of these students; and, (ii) to address how the student could benefit and apply newly acquired knowledge when returning to their home environment.

This paper summarizes a successful experience carried out at The University of Oklahoma (OU) in which an integrated approach was implemented within NSF's S/IUCRC (State/Industry/University Cooperative Research Center) program. A Ph.D. dissertation topic in the School of Petroleum and Geological Engineering was defined to specifically tackle a serious problem faced by Petrobras in the development of the hydrocarbon reserves located in the deepwater portion of the Campos Basin. This problem was already being investigated inside the company through an internal project conducted with the Catholic University of Rio de Janeiro (PUC-Rio). However, a deeper and more profound understanding of the associated phenomena was needed and the company decided to pursue this through a graduate research program. The selection of the university was based on the available experimental facilities appropriate! to conduct the necessary tests and also due to the existence of an industrial consortium (Rock Mechanics Consortium (RMC)), offering the possibility of exchanging field and lab experience with several oil companies.

This paper describes all the steps of the program, considering the viewpoints of both the company and the university. By combining field and business experience, theoretical support, interaction with other experts in the area, field data and samples, and strong support from the companies, the project was defined and initiated in order to complement the one carried out by Petrobras. Constant information exchange was essential to continuously redirect future plans, always aiming at maximizing the learning curve. The paper concludes with recommendations on how to improve the efficiency of current engineering programs and, at the same time, maximize the benefits for both the University and the student.

Introduction

Any educational program should be able to provide a profitable experience for both sides: the University and the student. This point is especially important for foreign students. Differences in life-style, culture, and, principally, language can, indeed, make such an experience very frustrating if adaptation to the new environment takes too long. When spouses and children are also involved, the adaptation can turn into a critical issue. Hence, it is important to include the family int he overall effort, either by socializing with other graduate students and/or by making them part of the success in passing the various hurdles such as Qualifying Exams.

This paper describes a doctorate program conducted at The University of Oklahoma in the School of Petroleum & Geological Engineering from 1994 to 1997 [1]. The main points of the program, the definition of the program, selection of the University, and the main results obtained are presented. The program has some particularities because it was sponsored by a company with a strict time constraint. Emphasis is given to the benefits provided by the interaction with professionals of several companies involved in the Rock Mechanics Research Center.

Defining the Program

Since the studies would be sponsored by a company, the research theme focused on some specific problem(s) in which the company was directly interested. At the time the program was being defined, wellbore stability problems in the shale sections of wells drilled in deepwater, Campos Basin, were increasing the development costs of big fields. In order to optimize the drilling operation and, consequently, reduce the overall costs of the exploitation project, shale stability was selected as one topic to be developed as part of the Deepwater Technological Program conducted by the company.

This project started in 1992 involving not only the Research Center, but also the operational unit, service companies, and universities in Brazil and abroad. Due to the complexity of the topic, the company approved a doctoral program on shale stability, with emphasis in Rock Mechanics. The idea was to allow a deeper understanding of the basic and fundamental mechanisms leading to the problems encountered in the

field. In addition, support to the Rock Mechanics Laboratory located in the company's Research Center was considered an interesting sub-product.

One of the most serious limitations faced by the program was the time limit established and later enforced by the Company. The overall doctoral program should not exceed 3.5 years, including all the requirements imposed by the University, such as course work, qualifying & general examinations, dissertation defense, etc. Due to this limitation, it is absolutely essential for the candidate to arrive at the University with a good idea of what will be his/her main focus. In this case, several questions had already been formulated by the project developed in Petrobras.

The doctoral program was approved and, therefore, initiated only two years later than the beginning of the project. During this preliminary ``preparation period,'' important issues were addressed, such as: collection of shale cores, definition of ways to preserve, as much as possible, the in-situ moisture condition, development of innovative tests to evaluate shale-fluid interaction, among others.

Selecting the University

The most important step in the whole doctoral program is the right selection of the university. Not always does the candidate have the opportunity to visit the university beforehand, which increases the uncertainties of success. Therefore, this step should be taken carefully, taking into consideration available facilities (including laboratories and computers) to develop the proposed program, interest from the Chairperson to advise the study, existence of critical mass of expertise, and mainly involvement of companies in the activities of the group. This last item is essential because it demonstrates the ability of the group to conduct interesting and applied research. Also, interaction with professionals from different companies allows the reduction of time to learn and develop complex points.

Petrobras had been involved in the Rock Mechanics Consortium at The University of Oklahoma since 1992. The Consortium, at that time in its first phase, was conducting 6 fundamental research projects with potential application to the oil industry, but none of them directly related to shale stability. One of the projects, however, focused on wellbore stability; mainly in permeable formations. The first phase was scheduled to end in 1994; and for the second phase, new topics were allowed to be proposed and ranked by the companies.

In 1992, the National Science Foundation (NSF), together with the Oklahoma Center for the Advancement of Science and Technology (OCAST), selected the University of Oklahoma to host the Rock Mechanics Research Center. The creation of a research center implies financial support from both the state and federal governments. This allowed a significant increase in the investment made by the companies in the Consortium. The recognition by the NSF and OCAST demonstrated that The University of Oklahoma had the best facilities in the nation.

It was not difficult, then, to select the most appropriate university to develop the proposed doctoral program in shale stability, with emphasis in rock mechanics. Even though some other universities conduct research in
this area, OU was the only facility to have all the necessary ingredients.

Outcomes, Goals Achieved, and Benefits

The first semester was dedicated to the student adapting to the new culture, including the family, and also identifying within the university sources of knowledge to be used during the program. The course work was defined with the advisory committee, including subjects within the geology department, also. The excellent infra-structure provided by the university, not only by the School of Petroleum and Geological Engineering, permitted a definition of a broad scope to be tackled. In addition, professionals of the companies affiliated with the Rock Mechanics Research Center were invited to participate in the discussion of the shale stability project, bringing valuable expertise. This interaction was responsible for a considerable savings in terms of the learning period.

In terms of intellectual capability, the Rock Mechanics Research Center has a unique team, composed of specialists in several fields, most of them related to rock mechanics, applied to the oil industry. This diversity of knowledge creates an environment prone to learning fast due to the availability on-site of experts who are aware of the latest developments in their field. This factor is extremely important when the doctoral program has a time limitation. By joining this intellectual capacity with excellent laboratory facilities, new tests could be envisioned to be developed to provide the necessary answers to the questions formulated.

A successful laboratory investigation in the oil industry field needs availability of downhole cores for the results to be representative and useful. Involvement of the companies in the consortium played a decisive role in this aspect. Cores from different fields in Brazil, Mexico, and the North Sea were provided. This diversity of cores allowed the development of a comprehensive laboratory investigation; so far, unique in the oil industry due to the extension and amplitude of answers provided.

Another important characteristic of the Rock Mechanics Research Center is the biannual meetings. In these meetings, company representatives help steer the different projects and continuously suggest new direction for the project, if necessary, based on their in-house

experience. During these meetings, the student had the opportunity to share his view and results with some of the most important professionals available in the area. The Shale Stability project was not an exception. Each six months the strategy of the project was reviewed by the ``mentors,'' the representatives most interested in the project, and this interaction and knowledge exchange were decisive in leading to the excellent results achieved. Some companies also participated directly in the project, conducting some standard tests in-house and sharing their data. This involvement not only saved money and time for the project but allowed comparisons between different methods for obtaining certain parameters!. Quite unexpectedly some methods led to discrepancies. Uniformity and standardization of such laboratory procedures is important in the sense that the parameters are used to design field operations.

The dissertation was part of the Shale Stability project. During the study innovative tests were designed and conducted to specifically answer some questions. A total of seven papers were produced during the student's tenure, before the defense of the dissertation, and five more papers have already been approved to be presented later on. A new methodology to characterize clay-rich rocks, using thermal analysis, and a new test to evaluate the reactivity of shales in contact with fluids are two new procedures that will impact the way the oil industry evaluates drilling fluids. In addition, several concepts currently used to design the drilling fluid have been proven not to be correct under downhole conditions, where the shale has its native water content. The old idea that shales are strongly reactive in contact with water solutions proved to be a consequence of inadequate handling procedures of the cores. The work finally proposes a totally new conceptual model to analy!ze wellbore stability using energy as the critical parameter. The aim is to effectively detect the right mechanism responsible for causing the problems, and therefore adopt the appropriate solution. The potential savings involved can reach US$ 1 billion dollars, an amount estimated to be related to wellbore stability problems.

Conclusions

The success of advanced educational programs, especially masters and doctorates, requires specific attention on some points. When the program is conducted for a foreign student, these points are much more important. Adaptation to the new culture, ability to understand and communicate in the new language, and advanced definition of the topic to be studied during the program are some of the key issues.

The paper presents a successful doctoral program conducted at The University of Oklahoma and discusses the main steps taken prior to admittance that helped the candidate to finish the program in a very satisfactory way. The points considered to make the difference in the program were:

. Good definition of the topic to be studied during the course;

. Selection of the appropriate university, i.e., with good facilities, know-how, and technical staff;

. Support by the companies involved in the Rock Mechanics Research Center,

providing expertise that speeded up the learning process.

Acknowledgments

The authors would like to thank Petrobras for the financial support for a doctoral degree at The University of Oklahoma, the National Science Foundation, the Oklahoma Center for the Advancement of Science and Technology, and the companies affiliated with supporting the Rock Mechanics Research Center and the Rock Mechanics Consortium.

References

1. Santos, H. A New Conceptual Approach to Shale Stability, Ph.D. Dissertation, The University of Oklahoma, School of Petroleum & Geological Engineering, 1997.