Global Clinics in Biotechnology: A Global Partnership between Industry and Academia

Anthony Bright[1], Rosa Buxeda[2], Lorenzo Saliceti-Piazza[3], Elsie Parés-Matos[4], Anthony Tran[5], Thomas Kelleher[6]

***Abstract* - In the XXI[st] Century, access to high-speed and internet communication poses an interesting paradigm in engineering and science education, relying on the capability of academia to incorporate a global and interdisciplinary conscience into students' learning. Industry has, for a long time, lead globalization efforts due to its world-wide business nature. With this in mind, the Global Clinic in Biotechnology was established through collaboration among two academic partners, Harvey Mudd College and the University of Puerto Rico, Mayagüez Campus; and an industrial sponsor, Amgen Manufacturing, Limited. Student teams from the universities, of diverse cultural backgrounds and different disciplines of study, were assigned an industrial problem to be solved as a team. Each university branch was assigned faculty and industrial mentors. Faculty mentors provided counseling on the project's theoretical concepts at their campuses. Industrial mentors provided expertise on the project's goals and applied experimental setup. Thus, the experience of networking students from different cultural and disciplinary backgrounds was facilitated by the mentors. Progress on project, and consulting among teams, were communicated weekly using teleconferences or videoconferences. This paper will expose in detail how the Global Clinic in Biotechnology was established, how academia and industry collaborated to define an industrial project, and how the experience incorporated a global and interdisciplinary experience on the student's educational profiles.**

Index Terms - Cross-cultural and cross-disciplinary education, Industry-Sponsored project based learning, Global science and engineering education.

INTRODUCTION

The theme of much recent debate in national forums is the accelerating pace of globalization in communications and business. The technical ability to communicate instantaneously and share information across great distances has blurred distinctions between local and global, leading to new forms and methods of work.

"Many advanced engineering designs are accomplished using virtual global teams—highly integrated engineering teams comprised of researchers located around the world. These teams often function across multiple time zones, multiple cultures, and sometimes multiple languages." [1]

To prepare students for the future challenges of practicing engineering and science in a global context, Harvey Mudd College (HMC) and the University of Puerto Rico, Mayagüez Campus (UPRM) have undertaken to support the activities associated with running several long term sponsored global engineering and science projects with teams of students from the partner schools and an industrial sponsor. In the case of the Global Clinics in Biotechnology, the industrial sponsor is Amgen Manufacturing, Limited (AML).

BIOTECHNOLOGY, KNOWLEDGE-BASED ECONOMIES, AND GLOBALIZATION

The completion of the Human Genome Project in 2003 has positioned biotechnology as a life science that will impact human healthcare for years to come. Within a span of ten years it is expected that roughly 50% of the advanced treatment medicines will be obtained through biotechnology. Biotechnology manufacturing companies are part of the so-called bioscience industries, which account for 1.2 million direct employments and 5.8 million indirect jobs in the USA [2]. The actual trends in global markets have created the conditions in which biotechnology provides a convergence of opportunities for economic development, as well as ways to improve the quality of life. Globally, the emergence of some government initiatives in biotechnology (in countries like Ireland, Singapore, and Puerto Rico), includes coalitions led by business and higher education institutions to reposition their economy frameworks to be more focused on favoring biotechnology over other technologies. These initiatives to foster knowledge-based economic development address the needs of high technology companies in areas such as: strong academic research institutions conducting basic research in biosciences, access to early-stage capital; successful transfer of government–funded basic research for product commercialization, specialized facilities, and a highly skilled workforce, among others. Academia plays an important role in the global innovation process; university factors are as important as costs in emerging economies and more important in developed economies [3]. The development of a bioscience workforce has being addressed by a wide range of educational initiatives, including the establishment of biotechnology degrees ranging from two-

[1] Engineering Department, Harvey Mudd College, Claremont, California, USA, abright@hmc.edu
[2] Industrial Biotechnology Program, University of Puerto Rico, Mayagüez, Puerto Rico, rbuxeda@ece.uprm.edu
[3] Industrial Biotechnology Program, University of Puerto Rico, Mayagüez, Puerto Rico, saliceti@uprm.edu
[4] Department of Chemistry, University of Puerto Rico, Mayagüez, Puerto Rico, epares@uprm.edu
[5] Process Development Department, Amgen Manufacturing, Limited, Juncos, Puerto Rico, trana@amgen.com
[6] Process Development Department, Amgen Manufacturing, Limited, Juncos, Puerto Rico, kelleher@amgen.com

year associate degrees to Ph.D. programs. Furthermore, strategies need to be developed by academia to use feedback from industry to deliver novel educational programs that meet the skills and educational levels needed in the interdisciplinary field of biotechnology and to graduate successful professionals.

THE INDUSTRIAL SPONSOR: AMGEN MANUFACTURING, LIMITED (AML)

AML is the Puerto Rico branch of Amgen, a Fortune 500 company that provides biotechnology products that support cancer care, treatment of anemia, rheumatoid arthritis and other autoimmune diseases.

AML started operations in Juncos, Puerto Rico in 1992 as a fill and finish facility, however, significant investments have brought an expansion of the manufacturing facilities with technology transfer of microbial and mammalian cell culture, recombinant protein purification, and the establishment of a Process Development Department (PDD). The total investment of $2,200 million is the largest in biotechnology manufacturing in Puerto Rico. The Global Clinic in Biotechnology was sponsored by Amgen and executed by AML's PDD scientific and engineering staff.

THE ACADEMIC PARTNERS: HMC AND THE GLOBAL CLINIC

A unique characteristic of the engineering program at HMC is Clinic. Clinic is three required courses (Engineering Clinic I, E111; Engineering Clinic II, E112; and Engineering Clinic III, E113) in junior and senior years. A team of four students (typically three seniors and a junior) work with an engineering faculty advisor on a client sponsored project for one academic year. Juniors are expected to take only one semester (half the juniors in the fall; the other half in the spring). The student team engages in the full range of professional activities associated with carrying out a project for a client from conception to completion. This direct experiential learning is the key feature of clinical practice for all professions. As professionals, we learn teamwork, leadership, planning, communication, ethical responsibility not in a classroom but from the example and conduct of our peers and mentors as participants of an authentic project experience. The philosophy of Clinic is at the heart of the new Global Clinic Program in Biotechnology between HMC and UPRM (see Figure 1 below).

THE ACADEMIC PARTNERS: UPRM AND THE INDUSTRIAL BIOTECHNOLOGY PROGRAM

Biotechnology has become a major driver of Puerto Rico's knowledge-based economy. In the past six years, the portfolio of investments in biotechnology manufacturing plants with expansions from multinational companies such as Amgen, have surpassed the $3,400 million mark. The UPRM has been a strategic partner in supporting biotechnology manufacturing through its Industrial Biotechnology Program. This program has contributed to an educational pipeline in biotechnology by providing:

- Outreach initiatives for high school students through the Biotechnology Summer Camp.
- Interdisciplinary BS degree in Industrial Biotechnology.
- Customized training to company employees at the Industrial Biotechnology Learning Center.

This roadmap has been possible by the strong support of an Industrial Advisory Board composed of top management representatives from multinational biotechnology companies. Among these initiatives, the undergraduate program has been instrumental in providing professionals with an interdisciplinary education, enriched with research and industrial internships.

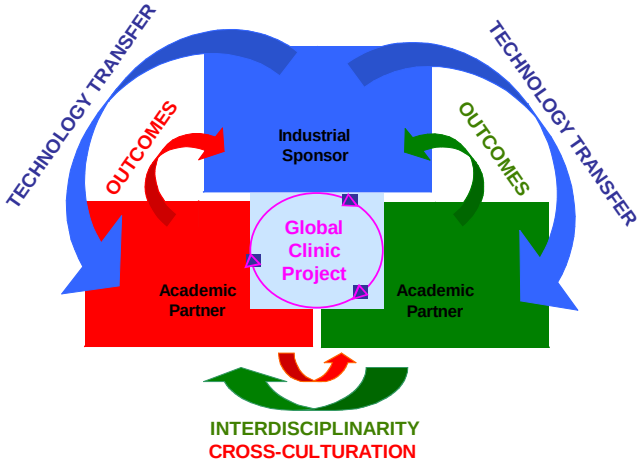

FIGURE 1
SCHEMATIC OF INTERACTIONS BETWEEN PARTNERS IN GLOBAL CLINICS.

CLINIC PHILOSOPHY

The clinic courses at HMC expose students to client-based design problems. Each year about 25 new clinic projects are initiated and taken to completion within the academic year. To date, over 1,000 projects have been carried out for some 250 different clients. It is designed as a teaching clinic, providing professional services to a sponsor company. Students participate under faculty direction and respond to client requirements through a company liaison who works with the team for the duration of the project. The significant characteristics of the clinic model of education are:

- Student as Self-Instructor
- Faculty as Coach
- Industry as Partner
- Learning as Collaboration

Mastery of a small subset of existing knowledge in a field is not a guarantee of expertise in a time when established bodies of information are becoming accessible at the press of a computer key anywhere in the world. The student who has not accepted the responsibility of his or her own continuous learning will be ill-equipped to survive in an age of global competition. Students need to be given every opportunity while at college to learn the necessary general skills of abstraction and synthesis. These skills can best be learned by practice on open-ended, unsolved problems under the guidance of experienced problem solvers.

The experienced problem solver is one aspect of the new role of the teacher, but it is the oldest tradition of teaching. The master and apprentice test their skills together on a shared task. As a coach, the teacher motivates, guides and encourages the student, observing and building upon the student's individual mode of learning.

In the global economy, the centers of industrial activity are always associated with the skills and talents of the professional problem solvers, problem identifiers and financial strategists, what Reich [4] calls the symbolic analysts, and Drucker [5] calls the knowledge workers. These individuals are at the hub of industrial wealth creation and bring their unsolved, untried problems to the places where they share solution methods with others of the same kind. This is the meaning of academic/industrial partnership. A constant supply of open-ended problems in all their rich complexity, both technical and organizational, is the essential resource on which the next generation of knowledge workers can practice.

The image of the solitary student, burning the midnight oil in an unheated garret, bravely struggling towards the moment of profound inspiration is part of the romance of nineteenth century fiction. Sharing problems, communicating concepts, seeking consensus, accepting help and criticism, are the realities of preparing for a successful working career. Collaboration with fellow students on an open-ended problem is a journey of self-discovery: learning to clarify ideas for others to understand; learning to move between leadership and followership; learning to negotiate a common strategy or argue for a new approach; learning to give credit to others.

If these characteristics are prized in engineering and science education now, then how much more relevant will they become when addressing the future education of engineering and science graduates in a global economy? To that end, AML, HMC and UPRM have launched a new Global Clinic Program to offer their students an integrated, multidisciplinary, multicultural program emphasizing professional engineering practice in international project teams.

GLOBAL CLINIC OPERATION

I. Step 1: Setting-Up the Stage: The Partnerships

- HMC approached Amgen and UPRM to meet and to present the global clinic concept. All stakeholders brainstormed, presented their strengths and needs, and determined to establish the partnership in an industry-sponsored Global Clinic in Biotechnology.
- HMC and UPRM faculty submitted a joint proposal to the company to appropriate financial support for the project.
- Subject matter experts from the PDD at AML submitted a list of potential current problems that the student team could work out as their clinic project.
- HMC, UPRM and AML discussed the portfolio of problems that needed to be addressed.
- The final clinic project was selected according to the company needs and academic resources. The research topic would have to provide both engineering and biotechnology aspects that would be worked out by each academic partner.
- Each academic partner identified faculty that would serve as the academia clinic mentors. Each faculty member from each institution was appointed team adviser to monitor progress and assist with facilitating team communications. The two faculty members would work cooperatively to ensure that the academic goals for the students were to be met.
- A team of three undergraduate students per academic institution was constituted. Criteria for student selection were based on academic performance and compliance with graduation requirements. All of the students were senior level undergraduate students.
- The industrial sponsor contributed an industrial liaison to support each academic partner.

II. Step 2: Team Building, Research Proposal & Cross-Acculturation

Key elements for the success of the project were:

- Development of teams within and across academic partners, and between academic partners and the industrial sponsor.
- Provide students an opportunity to understand cultural diversity on a global and international context.

- Provide acquaintance with the industrial sponsor values, work culture, and environment.
- Development of the bio-manufacturing process knowledge and experimental approaches to target the research problem, and based on those, to develop and to submit a proposal to the industrial sponsor.

The strategy to achieve these elements was carried out during the summer session. Students were to spend the summer before the academic year started in a program to prepare them for the culturally diverse environment of the partner school, including intensive language instruction and an extended visit to each campus for a project briefing with the other student/faculty/company members of the team. The student teams from each institution spent one month visiting each other's sites. During the summer, the joint team focused on initial project planning and taking part in an intensive team building/acculturation activities. At each site, students participated in:

- Technical and foreign language short courses.
- Cultural activities to learn about the culture and language.
- Literature reviews, discussion among teams and mentors to fulfill the experimental design, budget and proposal.
- A two-week industrial internship at AML for students to learn about biotechnology, bioprocessing, regulatory affairs, safety, and discussion of the proposed clinic project with the industrial liaison experts.

The outcome of this step was the submission of a research proposal to the company by the end of the summer session. The proposal included:

- Literature search and overview.
- Project objectives.
- Proposed work plan.
- Experimental design.
- Budget.
- Milestones and work schedule.

III. Step 3: Experimental Setup and Performance

This step involved one full academic year, an eight-month period. Each academic partner prepared the laboratory settings to perform the proposed experimental approaches. This involved purchasing reagents and materials, setting of equipment, developing laboratory protocols and hands-on experimentation. Protocols were followed and weekly video/audio conferences among academic and industrial partners were performed to discuss and share research data, to provide feedback and to modify experimental approaches or search for new avenues.

IV. Step 4: Final Outcomes Presentation

One midyear progress report and oral videoconference presentation was programmed to present the preliminary results to a group of industrial sponsor top management personnel. After completing the full academic year, each team prepared a joint final report on the research outcomes and stated their contribution to the project execution. In this final step, all teams presented their projects at the HMC Project Day and latter moved to the AML site to provide a final oral report.

CLOSING REMARKS

Traditionally, academic institutions provide students with industrial internships or Coops with the objective to expose students to an industrial environment. Globalization, advances in technology, and the rapid evolution in industry require engineers and scientists with a strong academic background, understanding of the industrial culture, efficient problem solvers, capable of communicating and to be long-term learners. Furthermore, the business request professionals that can think globally. The Global Clinics goes beyond a traditional internship to address the rapid gait of biotech companies.

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