A RESEARCH-BASED LEARNING APPROACH FOR UNDERGRADUATE STUDENTS

The Internship Program in Research and Innovation Model

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Abstract: World-class universities have usually been recognized for their intellectual contributions, and key ones are the products of the research (publications, patents, innovations, technology developments, spin-offs, etc.) they perform, and the impact these products have on the technological and economic development of regions of influence. After a literature review process and the review of how research activities with undergraduate students are promoted and coordinated in top ranked universities, the authors suggest three different approaches a university can follow for integrating research-based learning into the undergraduate curriculum: the stand alone approach, the attachment approach and the inserted approach. In the inserted approach an undergraduate student is interested in doing research out of her/his personal interest and the university supports these students by integrating them into research groups. The experiences and results of designing and implementing the inserted approach in the *Tecnológico de Monterrey* are presented in this paper, together with the integration of this program in the Knowledge-based Development model of the University that integrates the Research Chairs and Incubation Cells initiatives.

1 INTRODUCTION

The need for developing and deploying adequate research and innovation human resources as part of any country's economic development and long-term growth is well recognized. To compete globally, countries need a greater number of experienced people that follow a career path in knowledge economic research, with projects that seek the development of technology and innovation in universities and industry. Nevertheless, in the current economic environment, motivating students to do research and generate innovation is a great challenge.

Research can be motivated in different phases of university studies. Traditionally, research has been a task for graduate students, but nowadays it is also being introduced early in undergraduate programs. Different initiatives around the world promote the development of an undergraduate research culture (Boyer Commission, 1998). Some of these initiatives are: the Reinvention Center at Stony Brook at University of Miami, the Reinvention Center for Undergraduate Research at Warwick, and the Council on Undergraduate Research.

The experiences and results of designing and implementing the inserted approach (as proposed by the authors) using Research-based learning techniques through the Internship in Research and Innovation Program (*IRIP*, *Modalidad de Investigación e Innovación*, in Spanish) in the *Tecnológico de Monterrey* is the case study that is presented in this paper. Main results and experiences during its seven years in operation (2004- 2010), and how this program is being integrated in Tecnológico de Monterrey's Knowledge-based Development (*KBD*) model (Bustani et al., 2006), together with the Research Chairs and Incubation Cells initiatives, is also described.

An action-research methodology was used for designing the *IRIP* described in this article (Reason and Bradbury 2004). The authors of this paper were

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responsible for a second cycle in the action research methodology, starting in 2008, with the reflection of the previous *IRIP* results, and planning, designing and deploying new strategies and a new academic program structure for the *IRIP*, which are presented in this work.

2 BACKGROUND

The top eight universities around the world were analyzed to identify the purpose and structure of main programs introducing research activities to undergraduate students, and the different approaches these universities use for deploying this programs.

The top eight universities were selected using the THE-QS Times Higher Education, World University Rankings (QS-Quacquarelli- Symonds, 2009) and the ARWU: Academic Ranking of World Universities (Shanghai Ranking Consultancy, 2004). The universities selected are the ones that appear in 2009 in one of the following top 5: THE-QS general rank, the THE-QS citations per faculty rank.

These top universities (Harvard University, Stanford University, University of California, Berkeley, University of Cambridge, Massachusetts Institute of Technology, California Institute of Technology, Yale University and University of Oxford) offer their undergraduate students different opportunities for doing research in different formats using research-based learning concepts. Some programs offer academic credits, scholarships or student wages for participation in research projects during an academic year or summer period; others have available funding mechanisms that may be requested either for the student or for the tutors. Several programs are managed by the Undergraduate Advising Office, others by the student employment office, and still others independently by each department in the university.

Different strategies are also deployed by these universities to promote and display the information related to undergraduate students. Useful information is available on each web site, for example: the information about the office for undergraduate research, the list of academic departments and research advisors, a list of research opportunities (actual projects in and outside), a list of introductory seminars for doing research, information for getting funds, information about journals for publishing research results, research standards, and intellectual property rights policies.

Principal means for promoting undergraduate research results identified in these universities are: research newsletters, undergraduate research journals, symposiums, conferences, workshops for undergraduate research, undergraduate student research associations, and different student groups focused on research and innovation.

3 APPROACHES FOR INTRODUCING RESEARCH ACTIVITIES TO UNDERGRADUATE STUDENTS

From the literature review and the analysis of different universities, the authors identify three approaches that can be used in a university for introducing research activities to undergraduate students. These proposed approaches use Research-based Learning techniques (*RBL*).

3.1 Stand Alone Approach

The research task is introduced to all students in a classroom and promoted by the researcher. The professor responsible for the course is the advisor, and the students develop the research, generating a research report. In some cases this report can be formatted into a research paper and evaluated for its publication in a formal research environment (usually a conference). The main advantage of this approach is student integration into research activities, using a formal learning technique, but limited to the restrictions of an academic course in terms of time and resources. Research results may vary depending on the abilities of a single student for doing research by himself / herself. The stand alone approach is commonly used in several courses at different universities, and it is a common practice in summer research programs.

3.2 Attachment Approach

The student has to do a research task as a requisite for graduation and the task is usually based on a research profile defined for the bachelor degree. The student is “attached” to a professor developing a complete research project in a specific topic (usually within the professor’s main research interest). A technical research report is generated by the student. This report can generate a publishable work in the format of a poster or an article in a conference. At some universities, this is the case for some bachelor degrees, such as the *Bachelor of Science in*

Chemistry, where one requirement for graduation is to develop a research project and turn in a formal research product or report. Research results under this approach may have a larger scope, but the approach has limitations in terms of time, and resources may be low, since the main objective is to deliver a formal research report, usually in a thesis format.

3.3 Inserted Approach

An undergraduate student is interested in doing research out of her/his personal interest and the university supports these students by integrating them into research groups. The students gain the experience of working in collaborative research environments, in addition to developing different research skills. A special certificate is given to the student completing the research courses and work. Research results are intrinsically generated, since these are the logical outputs of research projects. The main advantage of this approach is the experience and the rapid integration of undergraduate students in the research project when working in a collaborative research environment, where senior researchers, PhD students, and MSc students are involved.

In the inserted approach researchers and students can get results more rapidly, as they are participating in well-established, long-term research projects which usually can get financial support easily. Most of the students who work under this scheme go on to complete a master or a PhD degree.

The sum of research group efforts in the inserted approach means rapid project results in the short term because specific research areas are consolidated. This contrasts with the "stand alone" approach in which the results are diluted and usually within a narrow scope.

4 INTERNSHIP IN RESEARCH AND INNOVATION PROGRAM (*IRIP*)

The *IRIP* began in 2004, supporting the *KBD* model and using the research-based learning technique. The main motivation of *IRIP* at *Tecnológico de Monterrey* is the development of research abilities and skills in undergraduate students through a formal process (learning by doing) that involves training in basic research skills and the opportunity to gain experience through participation in a research project, with specific responsibilities and committed results. Thus, the students are integrated to the Research Chairs and to the Incubation Cell for Technology-based Entrepreneurship Program of the University as described in the following paragraphs.

4.1 Research Chairs and the Knowledge-based Development Model

The *Knowledge-based Development* (*KBD*) model of *Tecnológico de Monterrey* grounds the inserted approach used by the *IRIP*. This model was created with the objective to contribute to 2015 mission statement and, specifically, one of its strategies, "re-focus research and extension activities". The *KBD* model consists of six components: (1) an institutional mission statement, which is the central guiding element, (2) social, human and intellectual capital, (3) research products, (4) research funding, (5) entrepreneurial initiatives, and (6) the education model (Cantú et al. 2009); and has been deployed and implemented by means of the Research Chair Program *(RCP)*, and by the Incubation Cell for Technology-based Entrepreneurship Program.

A Research Chair (Cantú et al. 2009) is a group of researchers (professors, postdoctoral researchers, PhD, MSc and undergraduate students) specialized in a scientific domain and headed by a principal researcher. This program is the trigger force that activates research projects with institutional seed funding. The *Incubation Cell Program* intends to foster technology-based entrepreneurship among graduate students of science and technology disciplines. An incubation cell is proposed by a professor and is leaded by a PhD student from a research chair in which a technological product has been developed. Members of the cell receive institutional support which comprises tuition and living expenses scholarships, business plan formulation, intellectual property, office space at the incubator facilities, as well as training and coaching in legal, capital, fiscal or regulatory aspects on the incubation process.

4.2 *IRIP* Academic Program Structure

The *IRIP*'s academic program structure consists of four courses outside the curriculum and four internships (courses within the curriculum). Courses outside the curriculum are designed to develop basic research and innovation skills, these include: 1) methodology for research and innovation, 2) comprehending, evaluating and structuring scientific and technical documents, 3) intellectual property, 4)

development of technological entrepreneurial skills and 5) qualitative research methods. Courses outside the curriculum are equivalent to a four-hour a week class (1.5 credits), while research internships are equivalent to an eight-hour a week project (3 credits) during one term (16 weeks).

During the internships, students develop a specific research project monitored by a senior researcher within a Research Chair. Besides the experience gained when participating in research projects, students are expected to have participated in writing technical and scientific papers, drafting a patent, and presenting their research results in national or international events. Many students also take the opportunity to participate in research groups abroad, acquiring international research experience and creating technology-based spin-off companies.

4.3 Main Results

After six years in operation, the *IRIP has* grown and incorporated students from several disciplines. From four students starting the program in January 2004, the number rose to 204 students registered in the program in August 2010. On average each academic semester 23 new students are registered in the program, although during the last two years the average of new students is 38. The number of enrolled students (students taking courses in each semester) has also grown: in both semesters of 2010, between 79 and 98 students were enrolled in at least one course or research internship, which means that approximately half of the registered students were taking courses during each semester.

In terms of preparation of researchers, the number of graduated students has started to grow, especially during the last year. The total number of graduated students since 2004 is 72. It is important to mention that there is a delay in the achievement of results in this kind of program. Most of the students who enter the *IRIP* are in the initial years of their bachelor degree program and their insertion in research projects is gradual, so the results they achieve will be during their senior year. The authors expect the number of graduated *IRIP* students to grow during the next few years proportionally to the number of new *IRIP* students.

From May 2008 to May 2010 graduated *IRIP* students generated more than 92 scientific research products. These research products are distributed mainly as follows: participation in patents and inventions, national research awards, participation in international research competitions, papers in refereed indexed journals, papers in international conferences, posters in international conferences, white papers published on internet sites, technical reports presented in international internships, papers in national conferences and master theses developed during undergraduate studies. Besides these research products, the *IRIP* has also promoted participation in international and national research internships.

5 CONCLUSIONS

In this paper the authors have discussed the different approaches that can be used in a university environment to introduce research activities to undergraduate students. *Tecnológico de Monterrey* uses the "inserted approach", showing a different way to incorporate research into undergraduate student curricula. This approach, implemented through the Research Chair Program and the *IRIP*, has demonstrated successful results that have supported the deployment of the *Tecnológico de Monterrey*'s Knowledge-based Development (*KBD*) model, as part of one of the key strategies that is transforming the university into a research university recognized around the word. The development of intellectual capital, the creation of research products (technology developments, inventions and publications), the promotion of entrepreneurship, and the education of undergraduate students has been enhanced by the different *IRIP* strategies deployed together with the efforts of the Research Chairs.

REFERENCES

Boyer Commission on Educating Undergraduates in the Research University, 1998. Shirley Strum Kenny. *Reinventing Undergraduate Education: A Blueprint for America's Research Universities*. Stony Brook, NY: Stony Brook.

Bustani, A., Garcia, J. E., and Cantu, F. J., 2006. Strategies for moving from a Teaching University towards a Teaching, Research and Entrepreneurial University: the *Tecnológico de Monterrey* Experience. Institute for Knowledge and Economic Development's Proceedings of the *Ethiopia Triple Helix Conference*, Addis Ababa, IKED: Sweden, May 2006.

Cantú, F. J, Bustani, A., Molina, A. and Moreira, H., 2009. A Knowledge-based Development Model: the Research Chair Strategy. *J .of Knowledge Management*, 13(1), 154–170, 2009.

QS Quacquarelli Symonds, 2009. Top Universities. http://www.topuniversities.com. Accessed October 26, 2009.

Shanghai Ranking Consultancy, 2004. Academic Ranking of World Universities. http://www.arwu.org. Accessed October 26, 2009.

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