Major Issues in Designing an Undergraduate Program in Nanotechnology: The Mexican Case

ARMANDO BARRAÑÓN Department of Basic Sciences Universidad Autónoma Metropolitana Avenida San Pablo 180 MEXICO armandobarranon@yahoo.com.mx http://armandobarranon.freewebpages.org

ANTONIO JUANICO Nanotechnology Group Universidad Politécnica del Valle de México Av. Mexiquense s/n, Esquina Isla de Plata MEXICO jjuanico@upvm.edu.mx

Abstract: - Major Issues for developing an Undergraduate Program in Nanotechnology are hereby described. Nanotechnology Courses are designed so that students may apply the Nanosciences, Biotechnology and Information Sciences convergence model to develop new materials and applications Nanotechnology. Infrastructure and Human Resources turn out to be crucial for establishing a successful Nanotechnology Undergraduate Program. Several Mexican National Nanotechnology Labs will be cooperating for student internships and students may continue doing postgraduate studies at those centers of research. Societal and Environmental impacts of Nanotechnology are also addressed in the Undergraduate Program in Nanotechnology proposed in this article. Women participation is expected, considering recent statistics of women participation in undergraduate engineering programs related to Nanotechnology. Mexican government has been funding to the federal and state level the university where this program will be launched, as part of a national effort to provide universities all along the Mexican territory.

Key-Words: - Undergraduate Program in Nanotechnology, PROMEP scholarships, PRONABES scholarships, NBI model, Nanotechnology faculty, Mexico.

1 Introduction

Nanotechnology has generated a strong and special interest since the early twenty-first century from a famous lecture of Nobel Prize-winning physicist Richard Feynman in 1959 entitled "There's Plenty of Room at the Bottom". Nanotechnology promises to have a technological impact similar to that of the first Industrial Revolution where new views of work prompted machine based manufacturing. These new conceptions of human work were accepted by the large population educated during the Age of Enlightenment. By the end of the Renaissance, Descartes proposed the reductionist understanding of the human body in terms of the operation of an automaton whose defective parts could be replaced as happens with clocks [1]. Many artifacts were produced at that time that could also replicate human work so that machine manufacturing was ready to be set up afterwards, leading to Industrial Revolution. Also, at that time printed media spread out all kinds of innovations and the first technical Encyclopedia appeared in England, which secured social support for these innovations [2].

Industrial Revolutions involve educating people on new technologies so that a new labor force is developed. In the case of Nanotechnology, a new labor force in the range of two millions will be needed to support a market of about 3000 billions USD which is expected for 2014 that will involve other five million workers in fields related to nanotechnology. Fig. 1 shows how this new nanotechnology market will grow in the next decade [3] and some countries are preparing an educational framework based on nanotechnology since the beginning of the last decade [4]. Intercontinental alliances have been devised ever since to overcome the challenges involved in such a tremendous task. Educating this new type of workers will be a challenge in the short term and well funded organizations have supported these efforts to the national level, namely the National Nanotechnology Initiative Network that finances the attendance of selected undergraduate students to nanotechnology courses. Many countries in several continents are founding undergraduate programs in Nanotechnology, with minors in physics, chemistry, business and civil engineering, with an instructional time going from three to four years and offering also graduate programs in nanotechnology.



Fig. 1.- Shows the extrapolation Nanotechnology Sales in Billions of USD. Extrapolating to 2020, we obtain sales in the range of 13,496 USBD of nanotechnology products.

Social diffusion of nanotechnology will installment of nanotechnology guarantee the revolution and formal education in nanotechnology will be a way to institutionalize the efforts to instruct workers in nanotechnology. Since 2003, during a Meeting on Human Resources for Nanotechnology, held at Thailand, a call was made for experts educated in nanotechnology since it was very difficult to communicate between experts belonging to the distinct disciplines related to nanotechnology [5].

Nanotechnology undergraduate programs will provide individuals ready to train industries in nanotechnology, to implement outreach programs for school children, capable of developing crews of educators devoted to nanoeducation. Business majors with a minor in Nanotechnology will address the trade-off problems associated with the strict regulations needed to build up a safe market of nanotechnology products. Environmental problems related massive consumption to the of nanotechnology products have prompted the emergence of graduate programs on the toxicology related to nanotechnology. Recent economic crises derived from epidemics namely mad cow disease indicate the need of including social impact subjects in the curricula of these nanotechnology programs, which will provide experts on market regulations precautionary that include а approach to nanoproducts distribution in global markets [6]. Public opinion should have a positive attitude towards nanotechnology as well as being well informed on nanotechnology which has been promoted since 2004 by the first Encyclopedia of Nanoscience and Nanotechnology [7]. Also several programs have been developed to divulgate nanotechnology among children and general public. Nevertheless a drawback came out when the commercialization of a washing machine developed by Samsung and operating with silver nanoparticles was delayed by request of non government organizations in Europe. This was a clear evidence of the lack of social support as well as the poor flow information related to the benefits of of nanotechnology. Also, several groups of researchers on the social impact of nanotechnology have been skeptical on the possible benefits of this new technology and have expressed deep concerns about the segregation effects of nanotechnology due to the weak support for new technologies in the poorest countries. In Mexico a Nanoeducation Seminar was created in 2007 at UAM-Azcapotzalco with a Nanoeducation instructed by Dr. Aldrin Sweeny, Chief Editor of the Journal of Nanoeducation [8].

In the case of Mexico, science and technology policies change each six years when a new president is elected. Therefore, there is no continuity in the research efforts which has affected the settlement of a Mexican National Nanotechnology Initiative that could join all the small networks of Mexican researchers in nanotechnology. At the time, there are about 400 Mexican researchers involved in nanotechnology and working in groups with a mean size of 5. In spite of the strategic urgency of setting up a large network that could institutionalize these research activities, no official support has been granted in this direction meanwhile vast amount of official resources have been wasted in the failed military operations against crime. While in other countries like Korea, India, China and Brazil are considered as emergent already countries contributing to Nanotechnology up to a global level. Hence, Mexico nanotechnology activities are still unorganized with an incipient regulation of nanotechnology which delays the distribution of new nanotechnology products. Innovation has been included very recently as part of the activities

supported by the National Council of Science and Technology and few Mexican patents are registered. This profile explains the lack of competitiveness and the lack of innovation experienced by Mexican economy ever since twenty six years ago. The significant number of Mexican researchers involved on nanotechnology justify the convenience of official funding nanotechnology innovations as a priority to overcome this difficulties as long as international investment in Mexico has been decreased to a half of its value in 2009 [9]. Awfully, the Mexican National Council of Technology has recently agreed in 2010 to disassembling a nanotechnology research group classified as global top ten, which has awakened serious concerns among the Mexican nanotechnology community about the awareness of the governmental authorities on the strategic role played by nanotechnology on innovation as a means for solving the acute problem of competitiveness experienced be Mexican industry.

Studies published by CONACYT have shown the development of nanotechnology products by Mexican Nanotechnology Companies in the industrial settlement of Monterrey, Guadalajara and Mexico City with Mexican global companies using products. Consulting nanotechnology on nanotechnology has been done by several nanotechnology researchers but it is urgent to promote the creation of nanotechnology companies by scientists and businessmen. An Institute for Regulations is operating in Mexico with a chapter devoted to nanotechnology regulation and local companies are participating in the creation of new regulations that ensure the presence of nanoparticles in those products that affirm this in their advertisements. An alliance between local universities and companies is in course at Mexico to perform inspections that enforce these regulations. Undergraduate majors may provide individuals capable of doing these inspections in the labs funded by federal government to support Bachelors in Nanotechnology.

The involvement of Mexican companies with nanotechnology will ground future investigations to solve technological problems in a more efficient way using nanotechnology. This will improve the low competitiveness level of Mexican products. Mexican products would compete in terms of good quality instead of low labor costs. As long as companies are interested in the social acceptance of new products, private funding will help to use mass media and educational resources in order to convince public opinion.

Modifying curriculum include to Nanotechnology at universities may help to inform future leaders on the urgency of focusing social resources on the development of nanotechnology to the local and national levels. Educating on nanotechnology in the K12 level will secure social involvement on environmental problems related to new technologies. This requires the involvement of companies, local and federal governments as well as universities, in nanotechnology. Nevertheless, electoral studies show that Mexico is on the route of political fragmentation, where local leaderships turn out to replace institutional parties in the electoral preferences [10]. This could obstruct a national movement such as a National Nanotechnology Initiative supported to the federal level. As mentioned before, local authorities may impede the operation of a renowned nanotechnology research group in spite of the federal support to its activities in the form a 3M dollars funding for this very research group disassembled this year.

Nanotechnology is characterized by being multidisciplinary, it is of interest as the border of the chemical sciences, biochemistry, molecular biology, electrical engineering, also various physics. technologies as tools for manipulating atomicmolecular modeling molecular and atomic field microscopy, atomic, transmission and scanning. All this, not to mention their potential applications as cancer treatment, reduction of environmental pollution, filtering, new energy sources, etc., therefore, these issues must be addressed in the curriculum, from a scientific and technological perspective. Universidad de Guadalajara, Campus Lagos de Moreno organizes each two years an Interdisciplinary Seminar on Nanotechnology where undergraduate students attend lectures bv dedicated international researchers to nanotechnology studies. The nanotechnology laboratory provides optical means to certify the production of local milk industries, proving that a liaison between universities, government and local industries is viable.

Nowadays many universities and institutes in the world have academic programs with MS and Ph.D. in Nanotechnology or Nanosciences. However, current developments in nanotechnology require the opening of Bachelors in nanotechnology. The first university program involving nanotechnology was offered by the University of Toronto's Engineering Program, and afterwards Science Flinders University in Australia offered the Bachelor of Nanotechnology with optional area in biomedical nanotechnology. A lot of Universities around the world offer BS and B. Eng. in Nanotechnology or

Nanoscience, and Mexico is no exception with a rate of a Bachelor in Nanotechnology opened every year (Fig. 2), although opening this degree is not so simple [11-12]. There is few information Mexican Nanotechnology, which can be easily seen looking the report on Government policies at on Nanotechnology Worldwide, where only National University is cited in 2009 even when there are about 50 Mexican universities involved in Nanotechnology [13]. А recent book on Nanotechnology Research Advances published in 2009 included nearly 20 articles contributed by Mexican Researchers most of them belonging to Mexican Universities in the countryside [14]. National Science Foundation solicited this year Proposals for enhancing Nanotechnology Undergraduate Education (NUE) in Engineering [15] while in USA many universities have established Bachelors Science of in Nanotechnology.

In recent years several Mexican companies have been distributing and producing products based on nanotechnology, therefore a workforce trained in nanotechnology should be available in the following years at Mexico. Viral threats have been a major concern for Mexico in 2009 and this year a new disinfectant based on Mexican nanotechnology is being successfully tested on many viral and bacterial strands namely influenza H1N1, E. Colli, etc. Using this kind of nanotechnology products requires the development of new industrial methods of production where sound undergraduate training in Nanotechnology will be imperative.



Fig. 2.- Bachelors Degrees founded in Mexico.

The superiority of nanotechnology will solve strategic national problems which will lead to a so called Nanodivide where Nanotechnology may bring lot of benefits to the countries that participate as agents but that may also relegate those countries that will play the role of spectators in the Nanotechnology Revolution. successful А Undergraduate Program in Nanotechnology should be based in the well known group of convergent Molecular technologies namely Biology, Information Technology and Nanoscale Science. Undergraduate training in Nanotechnology will develop the new skills required by the novel nanotechnology Mexican industries which will lead to a better distribution of wealth. Nevertheless, governmental funding for Science and Technology is in the low range of 0.4% to 0.3% since 1997 which has been criticized by Nobel Prize Joseph Stiglitz. As The lack of proper funding of education, science and technology leads to a loss of competitiveness responsible for the acute loss in the GDP of 6.7% experienced by Mexican economy this year [16].

Mexican funding of experimental research in 2005 was about 5000 millions of Purchasing Power Parity units compared to 14000 millions of Purchasing Power Parity units invested by Brazil at that time. In spite of this low level of governmental support, more than 100 Mexican Nanotechnology patents are registered each year since 1997 [17]. Mexico is part of network of countries with scientific production in nanotechnology [18] and it is the second of the six countries with more scientific production in Nanotechnology in Latin America [19] (Fig. 3) and the third in patents (Fig. 4). These figures show that Brazil is stronger than Mexico and CONACYT has placed more emphasis on patents in recent years, therefore a larger production of Mexican patents is expected in the following years. According to a study of 2007, While in USA a patent is solicited for each 1800 habitants, in Mexico a patent is solicited for each 200 thousand habitants. A special program devised by CONACYT provides funds for new patents by means of a contest that selects the best inventions to be supported [20].

In spite of the federal interest in promoting research to solve local problems of the Mexican States, the State of Oaxaca is not participating in this efforts and lacks of groups dedicated to Nanotechnology although а course on Nanotechnology is offered in the last year of the BS in Mechatronics at Universidad del Papaloapan Loma Bonita. This program may be the first step in incorporating Oaxaca to Nanotechnology, although several postgraduate students in Nanotechnology Programs at other Mexican States are natives of Oaxaca and this suggests that in some years

nanotechnology research centers may be based at Oaxaca.

Governors of the richer Mexican States have been very much interested in developing Advanced Research Complexes. This has happened in Monterrey, Guadalajara and Mexico City concentrates a large number of resources for postgraduate degrees in Nanotechnology as well as National Labs in Nanotechnology. Baja California Norte has also made a great effort to develop Nanotechnology and other research centers are spread in the middle of the country Bajío.



Fig. 3- Publications in the field of nanotechnology by Latin American countries.



Fig. 4.- Bar graph comparing the generation of patents related to Nanotechnology in Latin America by country.

2 Problem Formulation

In the following we detail what kind of Infrastructure, Curricula and Human Resource will be required to launch the Nanotechnology Undergraduate Program proposed hereby.

2.1 Infrastructure

Nanotechnology necessarily requires experimentation based synthesis and on characterization equipment which is usually too expensive. This equipment may be obtained via research projects funded by Consejo Nacional de Ciencia y Tecnología (CONACYT), Secretaría de Educación Pública (SEP) and both Local and Federal Governments. Another instance is financial support from large private companies either national or from abroad. Other resources can be obtained by means of collaborations with large universities and institutes whose infrastructure is extensive in Mexico namely UAM, IMP, UNAM, IPN, CINVESTAV, CIQA and CIMAV. Besides the above financial sources, projects can be financed by the Incubator for Nanotechnology Research and Innovation in the Technology Park at Monterrey [21] or through bilateral programs as the International Cooperation Program between Mexico and the European Union [22].

Undergraduate training in this kind of equipment can lead to efficient support of the local nanotechnology companies where the quality of products based on nanotechnology can be certified with the help of these expensive and sophisticated instruments. Once more a strong relation between local companies, universities and governmental institutions can help to attain a proper funding of a Nanotechnology Undergraduate Education Program as well as to enhance the competitiveness of local Nanotechnology companies and the development of a safe regulation of Nanotechnology. A recent survey has detected the involvement of large and medium Mexican companies on nanotechnology production and commerce. CEMEX and Vitro are included in this group of companies that employ nanotechnology for their products. Dozens of Mexican industries are developing products based on nanotechnology, which has stimulated the appearance of consulting companies dedicated to assess businessmen in the commercialization of these new products. Health regulation is still pendent as long as nanoparticle effects on Health remain unknown while safety norms for workers exposed to these nanoparticles in a regular basis are still missing. which implies a precautionary approach by the companies. All this needs to be addressed by representatives from the industries, government and Health authorities. Ethical studies on nanotechnology concur on the need of protecting workers keeping them informed of the hazards involved in working with nanotechnology substances that can be extremely toxic due to the

high surface and large number of particles peculiar of them.

A. Equip	ment commonly used in Nanocharacterization
SEM.	
TEM.	
HRTEM.	
AFM.	
Raman.	
XRD.	
EELS.	
Others.	
B. Equip	ment commonly used in Nanosynthesis
Reactor	and equipment to:
Arc Meth	od.
_aser Me	thods.
Chemica	Vapor Deposition.
Ball Milli	ig.
Diffusior	flame synthesis.
Electroly	sis.
leat trea	tment of a polymer.
_ow-tem	perature solid pyrolysis.

Table 1.- Equipment required for Nanocharacterization and Nanosynthesis.

It is possible to obtain funds to acquire nanotechnology equipment for the Bachelor in Nanotechnology(Table 1) by means of projects supported by the CONACYT and the European Union taking advantage of the Seventh Framework Programme (FP7) administered by the office of UEMEXCYT. Mexico and the European Union will dedicate 20 million for research projects on themes ranging from nanotechnology to materials. metrology and manufacturing technology where each line of research will receive about 400,000 Euros and will run for three years [23]. The creation of an engineering degree in nanotechnology will improve local investment in nanotechnology, strengthening local companies that employ nanotechnology. Today four universities have Bachelor of Nanotechnology in Mexico (Table 2) and other universities are interested in opening this degree during 2010, namely Polytechnic University of the Valley of Mexico [24] and the University of Guanajuato [25]. Also, there are at least 58 institutions doing research in nanotechnology or nanoscience based in 20 Mexican States.

2.2 Human Resources

The number of universities offering a Nanotechnology Engineering Program in Mexico is growing at a rate of approximately one per year, and there are 87 academic programs related to nanotechnology [26-32]. There are more than 400 Mexican specialists in nanotechnology, and most of them have an excellent position in research within

and outside the country, making it difficult to recruit them as faculty in new universities.

Mexican Nanotechnology Research Groups have a mean size of 5 and networks of these research groups have been created recently although a Mexican Nanotechnology Initiative needs to be created in the near future [33]. The difficulty of hiring faculty trained in nanotechnology can be overcome with the help of the PROMEP Program for Faculty Improvement [34], but this relies on the preferences of faculty which is not always interested in doing postgraduate studies on Science and Technology

Name	Academic
	Program
UNAM at Ensenada	Nanotechnology
	Engineering
Tijuana Institute of Technology	Nanotechnology
	Engineering
University of La Ciénega at	Nanotechnology
Michoacán	Engineering
University of Las Americas	Nanotechnology
	and Molecular
	Engineering

Table 2.- Mexican Universities with a Bachelor in Nanotechnology.

Fig. 5 shows a correlation between the number of researchers funded by PROMEP and the number of PROMEP scholarships granted in engineering an basic sciences to the university where these researchers are based. These statistics prove that in several Mexican universities, faculty has participated actively in Mexican Nanotechnology although in some Mexican States their faculties are not involved yet in Nanotechnology.

PROMEP program has consolidated several Nanotechnology research groups in Mexico. Postgraduate Studies in Nanotechnology can be pursued by faculty and others at universities and institutes in Mexico such as Universidad Autónoma Metropolitana which has a Nanotechnology Network and a Nanotechnology Laboratory unique in Latin America. Universidad Nacional Autónoma de Mexico which has a General Network of Nanoscience and is classified between the 50 best universities worldwide. Instituto Potosino de Investigación Científica y Tecnológica which has a National Nanotechnology Laboratory I. Centro de Investigación y Estudios Avanzados with the National Nanotechnology Laboratory II. Instituto Mexicano del Petróleo with the Laboratory of Ultra High Resolution Electron Microscopy. Instituto Nacional de Astrofísica, Óptica y Electrónica with

National Laboratory of Nanoelectronics. the Instituto Politécnico Nacional with the Nanoscience and Nanotechnology Center. Centro de Investigación y Estudios Avanzados with a PhD. Program in Nanosciences; and Centro de Investigación en Química Aplicada, among others [35-42]. On the other hand there are universities from abroad such as Erlangen-Nürnberg, Toronto University, Cambridge, Sussex, Oxford, Rice, and Waterloo who offer graduate courses in Nanotechnology and Nanosciences [43-48]. Another way to obtain a degree in Nanotechnology is an online course in Nanotechnology offered by Oxford University who was the pioneer in these kinds of open university courses [49].



Fig. 5.-Correlation between the number of universities with PROMEP Nano Faculty (PNF) and an index that multiplies the percentage of PROMEP scholarships granted to that university times the percentage of these scholarships dedicated to Science and Technology.

The number of Mexican scientists in nanoscience and nanotechnology is nowadays insufficient to achieve a technological development in the shortterm. Many Mexican postgraduates are waiting for an opportunity to be repatriated and a new undergraduate program should offer job opportunities for them. Also, programs to educate faculty in nanotechnology will be needed in the following years as nanotechnology is being developed in the country. A larger number of scientists and technologists trained in nanotechnology is necessary to design national policies in nanoscience and nanotechnology that ensure global competitiveness.

CONACYT set up since 1991 a repatriation program that by 2001 ad provides funds to install 2000 Mexican postgraduates in Mexican universities. New faculty specialized in advanced technologies will enhance innovation in Mexico as well as patents registration [50]. Nevertheless, CONACYT repatriated 320 graduates in 2003 but this number was reduced to 104 in 2004, due to administrative problems in CONACYT [51].

Notwithstanding, statistics prove that the number of nanotechnology researchers does not depend neither on the GDP of the State where the university is based (Fig. 6) or on the excessive expenses by State Government (Fig. 7). This means that involvement in Nanotechnology relies always on a personal choice as well as on priorities of local companies and the development plan of the local government.



Fig 6.- Number of Nanoresearchers in a PROMEP nano research group versus GDP of the State where these groups are based.

Women can be recruited from local High School Students and statistics show that some engineering majors like Chemistry and Environmental (40% of women participation), Physical, Industrial ad Metallurgy (20%) have acceptable rates of women participation [52].



Fig 7.- Number of Nanoresearchers in PROMEP nano research groups versus Excessive Spending by the State Government where these groups are based.

Therefore a good number of women students could be allocated from these disciplines to the new undergraduate program in nanotechnology. As a

matter of fact several Mexican States lack faculty women and incorporating more women to nanotechnology starting from the undergraduate level will temper the segregation experienced by women in the group of faculty dedicated to nanotechnology. Statistics suggest that Women participation in engineering can be enhanced by PRONABES scholarships for undergraduate Hence special scholarships students. for incorporating women in this kind of undergraduate nanotechnology programs should mitigate the gender nanodivide experienced in Mexico [52].

2.3 Academic Programs

We believe that designing an Academic Program is essential for success of the Undergraduate Program in Nanotechnology. Such Academic Program must be consistent to new times, considering a comprehensive approach focused on technological and scientific research as well as involving students in the development of Nanotechnology Business Studies.

The academic Program (4.5 years) proposed by us hereby is shown in Fig. 8, based on Physics, Chemistry and Biology. This academic program has an emphasis on synthesis and characterization of Nanomaterials with areas of concentration in electronics, biology and materials.

Several universities have offered advanced materials development in their undergraduate programs. Penn State offers nanofabrication facilities with 1 and 10 class clean rooms for the Minor in Nanotechnology offered at that institution. And University of Wisconsin-Stout offers a B.Sc. in Engineering Technology with a minor in Nanotechnology, where students develop new nanotechnology manufacturing processes based on industrial needs. Therefore similar activities should be included in the curricula of our undergraduate program using the facilities of Mexican National Nanotechnology Labs.

Societal and environmental impacts of Nanotechnology are also addressed in the first year of our Bachelor, as required by the National Science Foundation since Nanotechnology may change our world and education in these dimensions is needed to attain an informed citizenry and a competitive workforce [15]. The University of Leeds at UK has included philosophical, ethical, environmental and economical studies on Nanotechnology as part of the modules of its B.Sc. in Nanotechnology. Several studies have indicated the open problems related to environmental impacts of nanotechnology, which is still remain obscure which may hinder the health of workers exposed in a daily basis to nanoparticles. Ultrafine particles are well known for their toxic effects and nanoparticles are expected to have the

FOREIGN LANGUAGE I	FOREIGN LANGUAGE II	FOREIGN LANGUAGE III
CHEMISTRY	CHEMISTRY	CHEMISTRY
BUVGICS	DUVCICS	DUVSICS
I	II	III
DIFFERENTIAL	INTEGRAL	DIFFERENTIAL
CALCULUS	CALCULUS	EQUATIONS
LINEAR	VECTOR CALCULUS	MATERIALS
NIMAN	TECHIDI C IM	NANOTECUNOLOGY
DEVELOPMENT I	ENGINEERING	ENGINEERING
FOREIGN	FOREIGN	FOREIGN
LANGUAGE IV	LANGUAGE V	LANGUAGE VI
THERMODYNAMICS	COMPUTATIONAL	ELECTRONICS
manneemeana	CHEMISTRY	1
SOLID STATE	SOLID STATE	PHYSICS-
PHYSICS I	PHYSICS II	CHEMISTRY OF
		MATERIALS
01010	NUMERICAL	DOODADILITY
FUURIER	NUMERICAL	PRUBABILIT
ANALYSIS	METHODS	AND
		STATISTICS
PROPERTIES	MOLECULAR	ELECTRICAL
OF	MATERIALS AND	CIRCUITS
MATERIALS	NANOMATERIALS	
RESIDENCY	CHARACTERIZATION	CHARACTERIZATION
nearborier	TECUMIOUES	TECUMICALES
245	TECHNIQUES	TECHNIQUES
	1 contract	, II
FOREIGN LANGUAGE VII	FOREIGN LANGUAGE VIII	FOREIGN LANGUAGE IX
ELECTRONICS	MICRO &	SENSORS &
	NANOELCTRONICS	TRANSDUCERS
MOLECULAR		APPLICATION OF
MODELS	BIOLOGY	NANOTECHNOLOGY
		TO BIOLOGY
ALGORITHMS AND	DESIGN AND	REVERSE
PROGRAMMING	CONSTRUCTION	ENGINEERING &
SOLUTIONS	EQUIPMENT	BUSINESS
RESIDENCY	ENVIRONMENTAL	PRACTICAL OR
II.	PROBLEMS	RESEARCH STAY
CHARACTERIZATION	NANOMATERIALS	NANOMATERIALS
TECHNIQUES	SYNTHESIS	SYNTHESIS
III	1	

Fig. 8.- Academic Curriculum of Bachelor in Nanotechnology Engineering proposed by us.

same effects so that strong safety regulations need to be enforced on the basis of an ethical approach the secures the health of all the workers working in nanotechnology [54].

And the B.Sc. in Nanoscale Science at State University of New York Albany [53] is based at the mega research center CNSE where recently the field of Nanoeconomics has been included. At that place the first PhD in Nanoeconomics was granted in 2008. Research conducted at this Nanoeconomics group led to the conclusion that Nanotechnology requires new manufacturing strategies to attain a convenient technological and economical route. The Nanoeconomics group is part of CNSE a \$4.2 billion nanotechnology research center with a 2500 peoples affiliated as scientists, students, faculty and technicians. CNSE holds Summer Internships for undergraduate research every year in several fields of Nanotechnology including Mexican Students in these experiences.

Industry internships are proposed to be held during three courses, namely Residency I and II, Practical or Research Internship. Griffits University also devotes the third year of its undergraduate degree in nanotechnology to an internship in an industry or research laboratory. And the University of Technology at Sydney offers a Bachelor of Arts in International Studies with nanotechnology as optional, where students may be nanotechnology professionals aware of the international contexts of nanotechnology.

An optimal way of majoring the students is by means of a major project on nanotechnology. This has done by several Australian universities, namely U. of Western Australia, University of Adelaide, Curtin U. of Technology. La Trobe University. They include a major research project on nanotechnology as part of the last year of their undergraduate program in Nanotechnology.

Hence this Bachelor in Nanotechnology will make every effort to provide internships to educate undergraduate student in new materials development, teach them on the ethical issues related to nanotechnology, make them aware of the economical concerns related to the development of Nanotechnology industries.

3 Conclusion

We conclude that all conditions are met to properly establish this new Undergraduate Program in Mexico, in terms of infrastructure, human resources and the group of courses offered to the students. As explained before, this undergraduate program complies with the requirements of several other nanotechnology bachelors in Australia, USA and UK. As long as a Mexican faculty devoted to nanotechnology has been majoring postgraduate students in nanotechnology since many years ago, it will be easy to hire experts in nanotechnology to strengthen this Bachelor in Nanotechnology. Involvement with local companies and keeping the actual government support will be crucial for having success. Providing technical service to local industries may also help in achieving a better distribution of wealth in the surroundings of the University where this Undergraduate Nanotechnology Program will be based. A.B acknowledges the support of a Postdoctoral CINVESTAV Fellowship at granted by CONACYT-48795 Fund.

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