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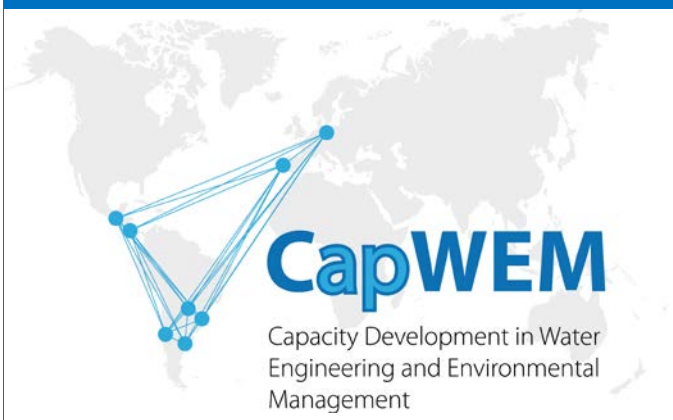
IMPROVING HIGHER EDUCATION IN WATER RELATED TOPICS: UNDERGRADUATE PROGRAMS



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Edited by Jürgen Steinbrecher,
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CapWEM Series

Capacity Development in Water Engineering and Environmental Management

Editors

Jürgen Steinbrecher • Ingrid Althoff • Helge Bormann • Hubert Roth

Volume 1A

Improving Higher Education in Water Related Topics: Undergraduate Programs

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Part 1

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PREFACE

CapWEM stands for “Capacity Development in Water Engineering and Environmental Management“ and was a joint project of universities from eight countries in Latin America and Europe: Argentina, Brazil, Chile, Costa Rica, El Salvador, Paraguay, Portugal and Germany. The University of Siegen in Germany was responsible for the coordination of the project.

CapWEM’s main objective was to improve higher education and enhance competences of professionals in the topics of water and environment in the Latin American partner countries. These targets were achieved by fostering academic cooperation between Latin America and Europe and establishing networks, aiming to create opportunities for sustainable collaboration both inside and outside academia.

Latin American countries are facing enormous challenges in terms of ensuring good water quality, equitable access to clean water and protection against water-related hazards like floods and droughts. Universities play a vital role within the process of meeting these challenges by training the future experts according to the state of the art. In addition universities should provide professionals in practice with recent research results and extend their knowledge. In order to achieve socio-economic benefits, the higher education institutions must be open for collaboration with public authorities and private companies. Finally they should contribute to increase public awareness regarding environmental protection and the proper use of water.

CapWEM organized its activities in different working groups covering the topics of improving Higher Education in undergraduate, graduate and doctorate programs; fostering continuing education for professionals; promoting cooperation between higher education institutions and private/public sector by technology transfer, common work on guidelines/norms and increasing environmental awareness; improving risk management, especially in cross-border watersheds.

CapWEM ran over a period of three and a half years from 2011 until 2014. The main outcomes of the project are published in this series. The project has been funded by the EU programme ALFA of the Directorate-General EuropeAid under the contract number DCI-ALA/ 19.09.01/10/21526/254922/ALFAIII (2010)55. ALFA stands for "América Latina - Formación Académica" and is a programme to support the institutional cooperation between higher education institutions in the European Union and Latin America.

The intensive collaboration among partners and their effective engagement over a period of more than three years fostered comprehensive results and experiences. Seven project meetings took the CapWEM team to all participating universities in order to consider regional adapted problems and solutions. A huge number of students and professionals could benefit from CapWEM’s activities. We expect that the project results will have positive impact on socio-economic development and help to face the challenges in the topics of water and environment in Latin America more efficiently.

The Editors

PRESENTACIÓN

El proyecto "Desarrollo de Capacidades en Ingeniería del Agua y Gestión Ambiental"; conocido por sus siglas en inglés como CapWEM (Capacity Development in Water Engineering and Environmental Management) fue un proyecto conjunto entre universidades de ocho países de América Latina y Europa: Argentina, Brasil, Chile, Costa Rica, El Salvador, Paraguay, Portugal y Alemania. La Universidad de Siegen en Alemania fue responsable de la coordinación del proyecto.

El objetivo principal de CapWEM fue mejorar la educación superior e incrementar las competencias de los profesionales en las temáticas de agua y medio ambiente en los países socios de América Latina. Estas metas se alcanzaron mediante el fomento de la cooperación académica entre América Latina y Europa y el establecimiento de redes, con el objetivo de crear oportunidades de colaboración sostenible, tanto dentro como fuera de la academia.

Países de América Latina enfrentan enormes desafíos en términos de asegurar una buena calidad del agua, el acceso equitativo al agua potable y la protección contra los riesgos relacionados con la ocurrencia de amenazas hidrológicas, principalmente inundaciones y sequías. Las universidades desempeñan un papel vital en el proceso de responder a estos retos mediante la formación de los futuros expertos de acuerdo al estado del arte. Además las universidades deberían proporcionar a los graduados durante el ejercicio de su profesión los resultados de sus recientes investigaciones a fin de permitiries ampliar sus conocimientos. Con el fin de lograr los beneficios socioeconómicos, las instituciones de educación superior deben estar abiertas a establecer vínculos tanto con las instituciones públicas como con las privadas. Finalmente, deben contribuir a aumentar la conciencia pública en materia de protección del medio ambiente y el uso adecuado del agua.

CapWEM organizó sus actividades en diferentes grupos de trabajo cubriendo los siguientes temas: mejora de la educación superior en los programas de pregrado, postgrado y doctorado; fomento de la educación continua para los profesionales; promoción de la cooperación entre las instituciones de educación superior y los sectores público y privado mediante la transferencia de tecnología, el trabajo común sobre directrices y normas y el aumento de la conciencia ambiental; la mejora de la gestión de riesgos, especialmente en las cuencas transfronterizas.

CapWEM se ejecutó durante un período de tres años y medio partir del año 2011 hasta el 2014. Los principales resultados del proyecto se publican en esta serie. El proyecto ha sido financiado por el programa ALFA de la UE de la EuropeAid Dirección General bajo el número de contrato DCI-ALA/19.09.01/10/21526/254922/ALFAIII (2010) 55. ALFA significa "América Latina - Formación Académica" y es un programa de apoyo a la cooperación institucional entre las instituciones de educación superior en la Unión Europea y América Latina.

La intensa colaboración entre los socios y su compromiso efectivo durante un período de más de tres años ha producido resultados y experiencias integrales. Siete reuniones del proyecto llevaron al equipo CapWEM a todas las universidades participantes con el fin de examinar los problemas regionales y ofrecer soluciones adecuadas. Un gran número de estudiantes y profesionales podrían beneficiarse de las actividades de CapWEM. Esperamos que los resultados del proyecto tengan un impacto positivo en el desarrollo socio-económico y contribuyan de manera eficiente a hacer frente a los retos relacionados con el agua y el medio ambiente en América Latina.

Los editores

PREFÁCIO

A sigla do projeto CapWEM significa "Desenvolvimento de Capacidades em Engenharia Hídrica e Gestão Ambiental". O projeto é coordenado pela Universidade de Siegen, da Alemanha, e foi fruto do trabalho conjunto das universidades de oito países da América Latina e Europa: Argentina, Brasil, Chile, Costa Rica, El Salvador, Paraguai, Portugal e Alemanha.

O objetivo central do projeto foi a ampliação de competências profissionais na área temática da água e do meio ambiente nos países parceiros da América Latina. Esse objetivo foi alcançado por meio de intensa cooperação entre os parceiros e a criação de redes, tanto na América Latina como entre América Latina e Europa.

A justificativa do projeto baseia-se nos enormes desafios que muitos países latino-americanos enfrentam em relação à garantia de adequada qualidade de água, à distribuição equitativa de acesso à água limpa e à defesa contra os desastres relacionados com a água, tais como inundações e secas.

As universidades desempenham um papel crucial para enfrentar esses desafios. Nelas, os futuros profissionais devem ser treinados e ter acesso às mais recentes descobertas em pesquisa e à educação continuada. A fim de desenvolver um efeito correspondente na sociedade, as universidades precisam expandir suas redes de cooperação e trabalhar com agências governamentais e empresas. Além disso, devem apoiar o processo de sensibilização social para a proteção ambiental e o uso adequado dos recursos hídricos.

Nesse contexto, CapWEM organizou suas atividades em diferentes grupos de trabalho. Os grupos foram divididos entre os seguintes tópicos: melhoria do ensino superior em todos os três ciclos: graduação, pós-graduação e doutoramento; estabelecimento de formação continuada nas universidades; promoção da cooperação entre universidades e instituições não-universitárias: transferência de tecnologia, desenvolvimento de normas técnicas, campanhas ambientais; melhoria da gestão de risco, particularmente em bacias hidrográficas transfronteiriças.

CapWEM foi desenvolvido entre os anos de 2011 e 2014. Os resultados mais importantes do projeto estão publicados nesta série de livros. O financiamento do projeto foi feito por meio do contrato n. DCI-ALA/19.09.01/10/21526/254922/ALFAIII (2010) 55, do programa ALFA da União Europeia, da Direção Geral EuropeAid. ALFA significa "América Latina - Formação Acadêmica", o qual é um programa para promover a cooperação institucional entre universidades da União Europeia e da América Latina.

A cooperação intensiva, durante mais de três anos, agregou uma gama de conhecimentos e experiências. As sete reuniões “milestone” do projeto levaram a equipe CapWEM a todas as universidades envolvidas no projeto, de modo a considerar as questões específicas de cada um dos participantes. Esperamos que, com a publicação dos resultados do projeto, possamos contribuir para enfrentar os desafios relacionados com a água e o meio ambiente na América Latina.

Os editores

VORWORT

CapWEM steht für „Capacity Development in Water Engineering and Environmental Management“ und ist ein Gemeinschaftsprojekt von Universitäten aus acht Ländern in Lateinamerika und Europa: Argentinien, Brasilien, Chile, Costa Rica, El Salvador, Paraguay, Portugal und Deutschland. Die Koordination liegt bei der Universität Siegen in Deutschland.

Zentrales Ziel des Projektes ist die Erweiterung der fachlichen Kompetenzen im Themenbereich Wasser und Umwelt in den lateinamerikanischen Partnerländern. Erreicht werden soll dieses Ziel durch die intensive Kooperation zwischen den Partnern und die Bildung von Netzwerken innerhalb Lateinamerikas sowie zwischen Lateinamerika und Europa.

Ausgangspunkt für die formulierte Zielsetzung ist die Tatsache, dass viele lateinamerikanische Länder vor enormen Herausforderungen stehen hinsichtlich der Sicherstellung hinreichender Wasserqualität, der gerechten Verteilung des Zugangs zu sauberem Wasser und der Abwehr gegenüber Katastrophen wie Überschwemmungen, aber auch Dürren. Hochschulen spielen eine entscheidende Rolle in dem Prozess, diesen Herausforderungen zu begegnen. In den Hochschulen werden die zukünftigen Fachkräfte ausgebildet, Hochschulen sollten aber auch im Rahmen der Forschung und Weiterbildung die aktuellen Fachkräfte mit neusten Erkenntnissen versorgen. Um eine entsprechende Wirkung in die Gesellschaft zu entfalten, müssen sich die Hochschulen öffnen und mit Behörden und Unternehmen zusammenarbeiten. Auch sollten Sie den Prozess unterstützen, in der Gesellschaft das Bewusstsein für den Umweltschutz und den angemessenen Umgang mit der Ressource Wasser zu schärfen.

Vor diesem Hintergrund hat CapWEM seine Aktivitäten in unterschiedlichen Arbeitsgruppen organisiert. Diese arbeiteten zu den Themen Verbesserung der Hochschulausbildung in den Bachelor-, Master- und Promotionsprogrammen; Etablierung von Weiterbildung in den Hochschulen; Förderung der Kooperation zwischen Hochschulen und außeruniversitären Einrichtungen durch Technologie-Transfer, Richtlinien- und Normenentwicklung sowie Umweltkampagnen; Verbesserung des Risikomanagements, insbesondere in grenzüberschreitenden Wassereinzugsgebieten.

CapWEM lief über einen Zeitraum von dreieinhalb Jahren von 2011 bis 2014. Die wesentlichen Ergebnisse des Projektes werden nun in einer Schriftenreihe veröffentlicht. Die finanzielle Förderung erfolgte unter der Vertragsnummer DCI-ALA/19.09.01/10/21526/254922/ ALFAIII(2010)55 aus dem EU-Programm ALFA der Generaldirektion EuropeAid. ALFA steht für "América Latina - Formación Académica" und ist ein Programm zur Förderung der institutionellen Kooperation zwischen den Hochschulen in der Europäischen Union und Lateinamerika.

Die intensive Zusammenarbeit über einen Zeitraum von mehr als drei Jahren war mit vielfältigen Erkenntnissen und Erfahrungen verbunden. Die insgesamt sieben Projekttreffen führten das CapWEM-Team an alle beteiligten Hochschulen, so dass landes- und hochschulspezifische Problemstellungen ebenso wie vorgefundene Lösungsansätze berücksichtigt werden konnten. Eine große Anzahl Studierender und Berufstätiger profitierte von den Aktivitäten. Wir hoffen, mit den Projektergebnissen zur sozio-ökonomischen Entwicklung Lateinamerikas beizutragen und die Akteure zu unterstützen, den Herausforderungen beim Thema Wasser und Umwelt besser begegnen zu können.

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IMPROVING HIGHER EDUCATION IN WATER RELATED TOPICS: UNDERGRADUATE PROGRAMS

General remarks

Universities represent an important link between engineering professionals and the environmental dimension, since they analyze and evaluate whether engineering activities have evolved in accordance with the perspectives of understanding environmental issues. This study suggests a comparative analysis of different existing academic fields. It analyses whether curricula are comparable, and whether modifications are required in order to meet the above-mentioned target.

During CapWEM implementation period different lines of action were developed based on the integrated work of the eight participating universities. This publication follows one of those lines, “Reform and modernization of relevant curricula”. The Focus is set on "Improvement of Higher Education on issues related to water" and aims at contributing to the improvement of the curricula of engineering careers in relation to environmental issues. In particular, it is related to undergraduates' training on water related topics.

This publication addresses the issue, analyzing, on the one hand, Civil, Environmental, Forestry and Agricultural Engineering academic careers of CapWEM participating universities and, on the other hand, analyzing accreditation requirements, which may be specific in the respective geographical areas.

The study cases allow the development of concepts combining professional and academic experiences. They are based on tools and reflections that should be taken into account when reviewing, modifying and updating the curricula in engineering careers.

Part 1 and 2 were written by the team of the partner university in Argentina, part 3 and 4 by the team of the partner university in Brazil and part 5 by the team of the partner university in Chile.

CONTENTS

Part 1

1 Importance of environmental training in engineering courses: Engineers as environmental actors

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1.1 Introduction

There are several reasons for the movement towards rethinking the engineering curricula. Some of them have to do with new problems faced by society: on the one hand, those resulting from a wider social and economic gap due to the technological revolution; on the other hand, problems linked to the use of natural resources; the demand for transformation through globalization, and the delay in facing problems related to meeting basic needs.

The Spanish and Latin American Association of Engineering Educational Institutions points out the efforts made in international forums to revise engineering programs on the basis of regional cooperation. It also refers to the need to differentiate regional academic cooperation from an opportunity for solidarity, integration and development. One of the most important regional challenges related to engineering is cooperation in preventive measures regarding the water crisis.

Engineering has always been a professional sector linked to the use of water resources, even at times when water policies were focused on the construction of physical and administrative structures to ensure consumption for the general public. Nowadays, an engineer's training will have to include water policies that are aimed at generating preventive strategic actions regarding the ever-increasing conflicts on water resources. (Cañon Rodriguez, J., 2010).

It is understood that the revision of engineering curricula includes several aspects that will need a common denominator so as to be turned into regional opportunities for the creation of preventive responses to ever-increasing water problems. This paper reflects on the current situation of universities concerning the environmental approach in engineering training.

1.2 Justification

There is a direct link between activities carried out by professional engineers and the environmental dimension. The relationship between development, technology, society and the environment is based on an integrated outlook and characterized by an understanding of reality and complex thought.

The problems faced by professional engineers exceed the competences acquired through traditional training, which has led to the need for an international revision of the role of the current engineer (World Federation of Engineering Organizations, 2010). Also at international forums the debate has come up on whether engineering should add the environmental and social aspects to the training of professionals (ASEE - CMC, 1989). The need to rethink the construction of thought in the training of engineers becomes apparent. This new kind of approach implies changing the perceptions of future professionals, by regarding problems from an integrative point of view.

Therefore, it is a challenge to develop a new curricula integrating fragmented knowledge, adding to complex problems faced by engineers, the competences beyond the training. A change in paradigm is then necessary to allow for multiple viewpoints that have to take into account economic, technical, social and environmental aspects. In this context, Universities need to analyze whether their engineering programs have evolved in the same direction as the understanding of such problems. This requires an evaluation of the compatibility between current competences offered in graduate and post-graduate programs, analyzing if they are adequate or, on the contrary, if they should be updated.

The complex nature of environmental problems, and those regarding water resources in particular, demand the kind of training that goes beyond mere scientific and technological contents, stripped of a context of the real problems that will have to be dealt with later on (García, R., 2006). The priority of environmental problems and their connection to technology are reasons to move towards a change in paradigm regarding the training of engineers. One solution might be not just adding new contents, but achieving a multidimensional approach including social and environmental viewpoints. Thus university programs facilitate the development of skills for teamwork with other fields. (Paris, M.C. et al., 2009).

1.3 Competences and accreditation process

An engineer's formation in different field-competences is a matter still under revision, as evidenced in several international forums. The creation of competences is an approach that goes beyond the usual scope of incumbencies. New professionals need other kinds of knowledge within new academic dimensions that had been so far excluded from the field of engineering.

In the light of these new requirements, universities face the need to analyze training offers, and evaluate whether they have evolved in the same direction as the understanding of environmental matters, the compatibility of current competences in graduate and postgraduate programs, and whether they are adequate or they should be updated.

Regarding the accreditation process, this tool has helped organizing and generating revisions within universities, but it has also established a structure that is very difficult to modify towards the changes needed in the curricula. However, we might also consider the accreditation process not as a rigid system requiring fixed standards, and have this as an opportunity for internal review and goal analysis. Engineering education should undoubtedly include the environmental variable, and it should also evaluate accreditation authorities.

1.4 Engineers as environmental actors

Identifying the role of the engineer as an environmental agent is fundamental when revising changes in training of engineering students. But this requires a change in the generation of knowledge towards more sensitive engineers, who will not only be managers, but also decision makers in their professional future.

The generation of knowledge requires change in paradigms: the perception of problems is now under an integrated point of view, including transferable knowledge with a natural and environmental base, built within the framework of institutions and standards. Policies are seen as tools for sustainable social development, adequately adding the interests of several actors. New skills and competencies must adapt to develop strategies that can generate internal institutional revision. Revision must be beyond the mere addition of content, permit changes, provide the opportunity to evaluate real problems faced by engineers and include all aspects of training (academic, research and extension).

From this perspective, changes in the curriculum are necessary as well as the generation of integration processes at all levels of education and training, with an institutional vision of engineering.

The dynamics of change, brought by the technological revolution and with the problems of the millennium, requires the acquisition of lifelong learning skills, understanding of emerging issues and critical capacity. Environmental problems have led to a crisis in the fragmented model of science and to a revision of the value of technology, based on knowledge that reproduced the fragmentation of reality and mediation in a paradigm of maximizing profits. This global change should incorporate a way of building knowledge where the actual process of teaching/learning is replaced by another one, which integrates social and environmental aspects to train students in reflecting on their general and professional knowledge.

1.5 Conclusions

The university's contribution to build an environmental rationality should start from the development of a scientific and technological rationality, within a transdisciplinary framework of approaches on environmental problems. This implies a redefinition of approaches that is not fragmented.

Furthermore, it includes the development of a technical rationality to create methodologies and tools. The environmental dimension must be addressed in the curriculum, and needs to build a professional ethical evaluation of the problem. We also suggest changing the habitual practice of preferring engineers for the teaching of subjects in other fields. It is better for the engineers' training to be offered wider views, and from other sectors, which is key for environmental issues. Qualitative characteristics of those curriculum changes also imply the need to involve the professor in a dialectical process that facilitates the generation of diverse points of view. The introduction of environmental matters in different subjects allows the construction of environmental rationality (Leff, E., 2009).

Building awareness spaces will also allow professors to develop skills that will help them in teaching students to identify the existence of problems and to find solutions in a holistic

approach. This may be solved with the creation of curricular subjects to solve complex environmental problems.

The University must as well revitalize its relationship with society, with real life and its problems as the strongest vectors in the revision of knowledge; learning from facts facilitates the generation of an ethic of commitment for students, teachers and the institution. The generation of knowledge under the scope of ideal conditions leads to training engineers in an isolated manner, out of a social context, and that perpetuating the causes of problems.

The University's challenge to train professionals who can deal with water problems will lead to the restructuration of engineering programs. This change will have to include the environmental aspect throughout the program. However, academic spaces will also need to change, in order to become more dynamic, flexible and to allow interchanging of knowledge in different fields of research, academic training, and in the relationship with society.

The value of the University is of a space fit for universality (from Latin universitas, meaning "all", "whole", "universal"), where the development of activities with different approaches will complement the curricula. It might turn into an adequate tool for interdisciplinary work, a necessary condition when dealing with water problems.

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Part 2

2 Environmental Training of Civil Engineers: An approach to the current situation by the analysis of the curricula

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2.1 Introduction

The contribution from Civil Engineering for the development of human societies evidenced in the history of the discipline, the oldest in the course of formal education (Watson, 2013). Such direct link to social development engages actors in rethinking its structure in regard to current social, economic and environmental needs. "Professional work through which human activities are planned, programed, projected or managed, are means of development and must be approached with the sensitivity and commitment of the environment perspective " (Gómez Orea, 2007).

A growing concern is observed in general in fields of discussion of science education and in particular in engineering careers regarding contents covered in the training of future professionals. This is reflected in the importance that has taken the discussion on improving the teaching of engineering careers, a widely discussed topic in recent years from national, regional and international levels in areas of discussion generated from the academic field and with participation of different sectors such as labor market, accreditation bodies, etc.

In the World Engineering Education Forum, different professional groups have extensively addressed the issue of the need for improvement in the teaching of engineering careers. Among participants were the internationally renowned agencies the American Society for Engineering Education (ASEE), the Iberoamerican Association of Institutions for Engineering Education (ASIBEI), International Federation of Engineering Education Societies (IFEES), the Global Engineering Deans Council (GEDC) and its regional representation through the Council of Deans of the Engineering Latin America Chapter, among others. These discussions raised the need of educating future civil engineers, as an essential component for the profession. They allow the expansion of a set of knowledge, skills and attitudes, which suggest a need for reform in the curricula for the development of the knowledge, skills and attitudes for future requirements (ASCE, 2010).

Directly linked to development problems, the making of environmental sustainability as a millennium goal highlights through its indicators the necessity of sustainable management in water resources (ONU, 2000). The identification of developmental issues in water resource management has become always more complex and preponderant,, because they affect the development of communities.

The main challenges among those listed to be improved by water management are droughts, floods, products of major extreme weather events and inadequate anthropogenic practices. Additionally, there may be cited the decline in quality of the resource and/or the quality of its exploitation, that directly affects the capacity of access to water and may cause major social conflicts. In the last decades, efforts have been made in finding solutions to the design of engineering works in order to improve water availability based on the increasing demand, considering an efficient resource management. This last paradigm requires building an integrated water resources management approach, because of the complexity of the problem represents. In this context, the University needs to analyze its curricular offers and to evaluate offers new perspectives of understanding the environment. This suggests analyzing the compatibility between the existing competencies of the academic offers and whether they are sufficient or, otherwise, if they should be transformed.

2.2 Comparative analysis of Civil Engineering curricula of participant Universities at the CapWEM project

This analysis is focused in the current curricula of Civil Engineering careers, of the participating Higher Education Institutions in CapWEM Project.

2.2.1 Objectives

From the comparative analysis of current curricula contents of the CapWEM partner universities, it is intended:

- ✓ To identify the characteristics of the offers, the problems or deficits of the curricular structures, as well as their strengths.
- ✓ To analyze necessary improvements or changes in the curricular structures of university education that promote integrated water resources management.

2.2.2 Methodology

The analysis considered different offers from Civil Engineering careers, reflected in the curricula of the selected universities.

In order to initiate the survey, data was established in regard to: general information about the career, the evolution of the matriculation, curricula structure, curricula contents. Based on relevant data of the main features of the curricula, a survey was designed in a form that was shared with the different participants in order to be completed with the data of each one of the universities.

General data regarded the year of creation of the career, modality, length, changes generated in the curricula, admission requirements and internships. Through this, different systems for implementing the same careers can be identified. For instance, it was inquired about the accreditation body of the career, length of the process and its period of validity. This issue is of fundamental importance when considering the need to rethink and reformulate a curriculum.

The research on matriculation was addressed through a table from which arises a graph indicating the evolution of incoming students and alumni between 2001 and 2010.

Moreover, data on the designation of the different component subjects of the career, the year of the same in which they are dictated and the contents programs corresponding to each one of the subjects in order to compare the specific contents, times of dictation and bibliography, were all used to address the questions in each university.

The collected information was complemented by a search task on academic information published on the websites of the respective universities.

Due to the heterogeneity in the interpretation and idiomatic meanings shared among the partners of the participating universities, it was necessary to unify criteria in order to make the collection of information useful and comparable.

In order to handle a common context and conceptual terms, the following meanings shall be considered:

Curricula:

The full career structure, organization, times, contents and modality of dictation.

Module:

Different stages throughout the career, identified by levels of study, blocks of similar thematic subjects, etc.

Subject:

Unit of study that addresses a particular thematic, generally of obligatory dictation and presence modality.

Seminar:

Unit of study that addresses a particular thematic, generally of elective dictation and not always presence modality.

With the collected information and in order to identify common contents, the classification of contents of the subjects was made corresponding to the academic degree of Civil Engineer. Were identified four groups: "Basic Knowledge", "Planning and Management", "Supply and Sanitation" and "Others." These groups were formed by the identification, in the contents of the programs, those that incorporate the topic water.

2.2.3 Obtained Results

The curricula structure of the eight careers of Civil Engineering analyzed was identified on the basis of the mentioned groups: "Basic Knowledge", "Planning and Management", "Supply and Sanitation" and "Others". (see Figure 1)

Degree	Topic	América Latina						Europa	
		Bahia Blanca Regional Faculty -	Santa María Federal University	Talca University	Universidad de Costa Rica	José Simeón Cañas Central American	Catholic University "Nuestra Señora de la	Superior Technical Institute - Lisbon	Siegen University
Bachelor	Basic Knowledge	Hidrology and Hydraulic Works	Hydrology I		Hidrology	Hidrology	Hidrology and Hidraulic	Hidrology and Water Resources	Hydraulic Engineering/Water Ressource Management I
		96 hours (2%)	60 hours (1,5%)		32 hours	85 hours (3.49%)	96 hours (2,11%)	6 ECTS (3,33%)	180 hours (3,33%)
					Hydraulic Infrastructures				Hydraulic Engineering II
					64 hours				150 hours (2.78%)
					Fluid Mechanics	Fluid Mechanics	Fluid Mechanics		Dynamics and Hydromechanics
					48 hours	85 hours (3.49%)	80 hours (1.76%)		180 hours (3.33%)
		General and Applied Hydraulics	Hydraulics I and II		Hydraulics I		Applied Hydraulics	Hydraulics I and II	
		96 hours (2%)			48 hours		80 hours (1.76%)	6 ECTS - ECTS (3.33% - 3.33%)	
					Hydraulics II				
					64 hours				
	Management and Planning	Environmental Management	GIS for Water Resourse Management	Environmental and Energy Management	Environmental Impact Analysis	Environmental Engineering		Civil Engineering and the Environment	Water Ressource Management II
		32 hours (0.68%)	45 hours (1.12%)	108 hours	32 hours	102 hours (4.19%)		1,5 ECTS (0.83%)	150 hours (2.78%)
		Final Project			Hydraulic Resources				Environmental Protection
		128 hours (2.74%)			32 hours				120 hours (2.22%)
		Environmental Impacts Identification in Sanitary Engineering Works							
		32 hours (0.68%)							
	Supply and Sanitation	Sanitary Engineering	Waste Treatment and Environmental Impacts		Environmental Analysis I	Aqueducts and Sewers	Sanitary Systems		Waste Water/Solid Waste I and II
		48 hours (1.02%)	60 hours (1,50%)		32 hours	68 hours (2.8%)	64 hours (1.41%)		120 hours - 150 hours (2.22% - 2.78%)
			Sewage and Urban Drainage Systems		Environmental Analysis II				
			60 hours (1.50%)		96 hours				
		Pumps and Pumping Installation	Water Supply and Treatment						
		50 hours (1.07%)	60 hours (1.50%)						
	Others	Sanitary and Gas Installations	Sanitary, Gas and Firefighter Building Installations						
		48 hours (1.02%)							
Total		11,21%					7,04%	10,82%	19,44%

Figure 1: Classification of subjects according to related contents to the topic water

Degree	Topic	América Latina						Europa	
		Bahia Blanca Regional Faculty -	Santa María Federal University	Talca University	Universidad de Costa Rica	José Simeón Cañas Central American	Catholic University "Nuestra Señora de la	Superior Technical Institute - Lisbon	Siegen University
		96 hours (2%)	60 hours (1,5%)		32 hours	85 hours (3.49%)	96 hours (2,11%)	6 ECTS (3,33%)	180 hours (3,33%)
Master	Basic Knowledge							Hydraulic Structures and Hydro Systems	Numerical Methods in Hydraulic Engineering
								6 ECTS (5%)	180 hours (5%)
								Fluvial Hydraulics and Rehabilitation	Hydraulic Engineering
								4,5 ECTS (3.75%)	180 hours (5%)
								Hydraulics and Maritime Works	Water Quality and Cuantity Management
								6 ECTS (5%)	180 hours (5%)
	Management and Planning							Environmental Impacts	Environmental Analysis
								4,5 ECTS (3.75%)	180 hours (5%)
								Environmental and Sustainability Challenges in Engineering	
								1,5 ECTS (1.25%)	
								Water Resources Modelling and Planning	Water Resource Management
								6 ECTS (5%)	180 hours (5%)
	Supply and Sanitation							Water and Wastewater Treatment Plants	Waste Water/Solid Waste
								4,5 ECTS (3.75%)	180 hours (5%)
								Sanitary Engineering	Water adjacent Constructions
								6 ECTS (5%)	
								Urban Drainage and Pollution Control	
								4,5 ECTS (3.75%)	
	Others								Water adjacent Constructions
									180 hours (5%)
								36,25%	35%

Figure 1: Classification of subjects according to related contents to the topic water (cont.)

Figure 1 presents the collected information with regard to the curricular contents related to the water topic. It is compared between careers for each one of the selected subjects, times destined for their dictation and their relevance according to these times in the overall context of the career.

According to the classification given above, in the "Basic Knowledge" group sets of comparable subjects according to their curricular contents were identified:

Group I: Hydrology, Hydrology and Hydraulic Works, Hydrology and Water Resources, Hydraulic Infrastructures, Hydraulic Engineering and Hydraulic Engineering/Water Resource Management, Hydrology and Hydraulic.

In this group, the following common contents were identified: Introduction to Hydrology, Evaporation and Evapotranspiration, Precipitation, Watershed and hydrologic processes analysis, Runoff, Hydrologic cycle, Hydrometrics, Infiltration, Statistics applied to hydrology, Floods, Unit hydrograph, Return period, Water resources development, Reservoirs and Dams, Alleviation works, Hydrologic budget.

Group II: Fluid Mechanics, Dynamics and Hydromechanics.

The contents of this group were: Introduction concepts, Statics of fluids, Kinematics and kinetics, Hydrodynamics, Hydrostatics, Flow in pipes and ducts, Open channel flow, Laboratory practical experiments, Sub critical and super critical flow, Laminar and turbulent flow.

Group III: General and Applied Hydraulics, Hydraulics I and II and Applied Hydraulics.

The following contents were identified in this group: Introduction concepts, Orifices and dumps, Permanent pressure flow in pipes, Open Channel Unsteady Flow, Hydraulic Machines, Water hammer, Laboratory exercises, Hydrostatics, Hydrokinematics, Hydrodynamics, Hydraulic physic models.

Within the classification "Planning and Management of Water Resources" the following subjects were contemplated: Environmental Management, Final Project, Environmental Impacts Identification in Sanitary Engineering Works, Geoinformation Systems for Water Resource Management, Environmental and Energy Management, Environmental Impact Analysis, Hydraulic Resources, Environmental Engineering, Civil Engineering and the Environment, Water Resource Management II, Environmental Protection.

Here were identified as common contents: Environmental Management Planning, Diagnostic, Introduction concepts, Environmental models, Environmental impact, Water Resources Planning, Prevention, Mitigation and Compensation Projects, Renewable energies, Water quality engineering, Environmental impact identification for potable water nets, sewers and water treatment plants, Legislation.

In the classification "Supply and Sanitation", the listed subjects are: Sanitary Engineering, Waste Treatment and Environmental Impacts, Sewage and Urban Drainage Systems, Water Supply and Treatment, Environmental Analysis I and II, Aqueducts and Sewers, Sanitary Systems, Waste Water/Solid Waste I and II and Pumps and Pumping Installation.

The contents of this group were: Sanitary and environmental engineering foundations, water quality and resources conservation, Urban water supply system, Water treatment, reservoirs, Distribution Network, Urban drainage, Sewer nets, Wastewater treatment, Effluent treatment systems, Residual sludge treatment and disposition, Pumping installations and operation.

It is noteworthy that, regardless of the denomination of the mentioned common contents, they were identified by the specific analysis of the topics covered in each one of them. That is, several universities have common topics developed but under different general description of the content.

Subjects related to domestic installations were classified as “Others”.

2.2.3.1 Analysis of results

It is worth highlighting that the total length of the careers in Latin American Universities is between five and five and a half years for the academic level of degree, while for European Universities this length is three years for the academic level of degree and two years for postgraduate academic level.

It is observed in this analysis that curricular contents that incorporate basic knowledge are located at the beginning and middle stages, while the contents associated with supply and sanitation are located in the middle and in the end of the career. Meanwhile, contents related to planning and management are observed in general in the final stage.

Regarding the time dedicated to the dictation of these contents, at undergraduate courses this ranges from 10% in Latin American Universities up to almost 20% in one of the European universities. In the case of postgraduate careers these contents reach 35%, observed in careers given in European Universities, as they are the only ones that dictate this level of training. By identifying dictation times of the different modules and their contents, and based on a comparative analysis of these data between the curricula of the different participant universities, the similarities and differences of each one of the careers involved were analyzed, considering the data obtained from study programs provided by the participants.

Regarding the basic knowledge, generally it is the same for all careers.

Regarding contents related to the management and planning (e.g. environmental impact, water resource management, etc.), Latin American Universities generally would require strengthening their curricula.

Other issues that would need to be strengthened from Latin American universities are the subjects related to supply and sanitation. In this sense, Brazil shows higher hour load and more subjects for that topic. However it should be noted that in other cases, such as Argentina, the contents are addressed from a single subject, highlighting the need to devote more hour load to it.

From this analysis, the difference in the infrastructure available in the different participating universities is inferred. There are subjects (in some cases, only contents) that are not taught

in all universities, responding perhaps to a lack of materials and equipment required for these issues (e.g. contents related to mechanics of fluids - Laboratory Practice).

2.2.3.2 Conclusions

The analysis of the contents of civil engineering curricula of partner institutions of CapWEM shows similarities at the way of addressing water issues between the European institutions on the one hand and, the Latin American institutions, on the other. This diversity could be a result of different contexts between Europe and Latin America, where the development, needs and maturity in the perception of environmental issues are different.

The need to incorporate additional contents related to environmental issues, in general, and water issues, in particular, in civil engineering curricula of Latin American universities seems to be evident. However, the solution is not to appropriate from the mere incorporation of contents, but structuring a series of seminars covering topics that properly complement the medullar academic training to the discipline. These seminars should also, as far as possible, relate curricular activity with referents of regulatory agencies, legislators and specialists from other disciplines. This would also improve the quality of the contents, for introducing students to the practice of interdisciplinary activity and creating a dynamic of common language.

From collected data it appears that the way of incorporation of environmental issues contents or, particularly related to water, are either isolated or fragmented. The current knowledge construction mode does not include integration of contents, but on the contrary, aims at a specialization that fosters such fragmentation and the difficulty to promote the complete visibility of the problems.

It is worth to note that the performed analysis was conducted on the base of the contents contemplated in the different study programs and, the existing academic freedom in the different universities must be considered. In this sense, it could happen that every teacher incorporates concepts that are not reflected in the plan subject, and changes the assigned time to each item, depth and focus of the development.

2.3 Reflections and final considerations

Considering activities related to evaluate and promote changes in the curricula of engineering careers, it was observed that, for participants, it would be essential in the engineer education to incorporate diverse and vast contents. This would consume time which in principle is not available, as all participants agree not to extend the length of the careers. In this context, the necessity arises to incorporate contents that may be addressed in flexible and adaptable proposals to the different careers of the participating universities. Redefining teaching in engineering includes multiple edges that must be a common denominator in order to allow new regional opportunities to work on a preventive response to the growing problems of water. Under this perspective, the approach to a curricula and study plans adapted to engineering studies would be facilitated, if it ensures:

- ✓ High level knowledge in water management and the environment
- ✓ Addressing local problems of interest in each region
- ✓ Enhanced practical skills

Then the challenge would be to define mechanisms that allow seeing these goals reflected from the incorporation of the environmental variable in a transversal way to the dictation of undergraduate level on a whole. This could be achieved by:

- ✓ strengthening students interest in environmental issues
    - o encouraging continuous training from initials stages
    - o generating elective courses of different issues related to water and environment
    - o promoting their participation in social volunteer programs
- ✓ making teachers sensitive to environmental issues
    - o creating workshops where common contents between the subjects and their correlation
    - o achieve optimization and consistency incorporating teachers who are dedicated to research as a way of incorporating these environmental issues from that point of view
    - o considering the need for participation of experienced teachers in professional practice in some topics, such as in the case of subjects related to works and projects
    - o promoting the importance of the approaching and analysis of local and regional problems from their integration to the contents of the lectures
- ✓ generating the commitment of institutional authorities
    - o as a way to have the topic incorporated into the development agenda of the institution
    - o as a trigger for incorporating the issue in the "attraction and implementation" of plans and programs for research and development in these areas
- ✓ promoting integration activities between Higher Education Institutions, in regional, national and international levels
    - o through the implementation of e-learning tools, virtual educative platforms, etc.
    - o encouraging the participation of teachers in academic exchange programs
    - o generating opportunities for student participation in academic exchange activities

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Part 3

3 Reform and Modernization of Relevant Curricula: Impressions from a Case Study

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3.1 Introduction

In recent years environmental issues have taken new dimensions, ceasing to be a restricted discussion to specialists and within environmental movement. The search for minimizing negative environmental interventions and implementation of new conceptions of the man/environment relationship attracted the attention of various sectors of the society, including the business sector.

Currently, environmental issues have been intensively discussed, due to concerns of various social groups warning the populace about the major environmental problems. Therefore, environmental education has been proposed as a means to educate individuals who are responsible for their actions which could jeopardize their very existence, because according to Travassos (2001) the fragility of the natural environment brings into play human survival.

3.1.1 Historical aspects of environmental education

At one International Conference on Environmental Education, held in 1975 in Belgrade, Yugoslavia, a communiqué on the principles and guidelines for a global program on environmental education was passed, which should be continuous, multidisciplinary, and integrate regional differences.

Two years later, in 1977, the 1st Inter-Governmental Conference on Environmental Education was held by UNESCO in Tbilisi, Georgia, where environmental education was clearly defined as the result of an orientation and articulation of diverse disciplines and educational experiences that facilitate the integrated perception of the environment. From this definition, it is essential that environmental education be structured around local concrete problems through an interdisciplinary and global perspective that would allow proper understanding of the difficulties (Bernardes & Prieto, 2010). The conference recognized the need for learning centers (from kindergarten to the university) remain in contact with the community and be preoccupied with the particular problems that are affecting their social groups. According to Loureiro (2006), this conference emphasized environmental education as capable of generating new values and attitudes, behaviors compatible with the

sustainability of life on the planet through a comprehensive educational (formal and informal) process.

Some years later, in 1987, the International Congress on Environmental Education and Training, held in Moscow, Russia, established the strategies of environmental education for the 1990s. At this meeting the role of university education and the need for the sensitization of the education authorities on environmental issues, the development of study programs in this area, teachers' training, and institutional cooperation were also emphasized, with a view to forming a new global ethic to promote the eradication of poverty, illiteracy, hunger, pollution, exploitation and human domination.

The holding of these conferences has been able to bring about rescuing and positioning environmental issues to the realm of educational institutions and enabled significant advances for the consolidation of progress and formulation of strategies to circumvent the problems and deficiencies of education in the environmental area. However, according to Dias (2004), for this new ethic to be able to consolidate the reformulation of educational processes and systems, a new relationship between teachers and students, schools and communities, as well as the society and educational system is required.

On this premise, the Brazil government in 1999 sought to include Environmental Education as a tool of educational policy in accordance with international guidelines and Law No. 9795 of 1999, otherwise known as National Policy on Environmental Education, was enacted, which deals with environmental education. In accordance to Law No. 9795 of 1999, environmental education therefore becomes an essential and permanent component of national education, which must be present in coordinated manner at all levels of the educational process and procedures to be developed as a continuous, integrated and practical education and permanent at all levels and types of education, without being deployed as a specific subject in the education curriculum. In relation to postgraduate and extension courses, it defines that the creation of a specific discipline would be optional and should be considered by those responsible for the need for its inclusion in the curriculum (Brazil, 2002). However, it is emphasized that, for the programs aimed at producing future teachers, environmental component must appear imperatively in the curricula at all levels and in different disciplines.

Arising from Law No. 9795 of 1999, which established the National Policy on Environmental Education in Brazil, National Environmental Education Program was created under the auspices of Ministries of Environment and Education. This program pointed to a new level of understanding of the educational process, with some pedagogical principles of critical and democratic dimension of environmental education. In addition, the National Curriculum Guidelines and the resolutions of the National Council of Education recognized Environmental Education as a subject to be inserted in the curriculum differently, not shaping up as a new discipline, but as a cross-cutting theme (Brazil, 2002). This action was, according to Leff (2002), the result of recognition that environmental education requires an integration of knowledge and systemic approximations, holistic and interdisciplinary approaches that are limited to the reorganization of available knowledge, are insufficient to meet this demand for knowledge. Thus, environmental education induces a developing knowledge in various scientific disciplines. Leff (2002) corroborated the principles of the

National Environmental Education Program and affirmed that interdisciplinarity is a process of exchange between different fields, thus becoming an indispensable tool for the consolidation and engagement of environmental education in the curriculum educational institutions. Thus, the legal instruments and government programs have strengthened the character assigned to interdisciplinary environmental education, which must pervade the contents of all the other disciplines, from early childhood education to postgraduate level.

However, all these principles, standards and guidelines have not been sufficient to overcome the debate on the creation of a specific discipline of Environmental Education generally or specifically related to water resources issues in basic or higher education. For this, it is necessary that environmental education is understood as a continuous process of seeking citizenship and justice, solidarity and sustainable development, thus it is a means and not an end. Therefore, the traditional content will only make sense for the society and who teaches and learn, if they are integrated into a comprehensive educational transformation project, to start with the school environment, involves the community and functionaries, rethinking of the physical space and school administration, teachers' involvement and student participation (Bernardes & Prieto, 2010).

3.1.2 Environmental education in the curriculum

In the case of Basic Education and High School in Brazil, the principal reference on environmental education are the National Curriculum Guidelines, prepared by many experts, compiled by the Ministry of Education and approved by the National Board of Education. Environmental education is included in the series of Transversal Themes of the curriculum framework and content aimed at providing education to the environment, with focus on cultural and environmental diversity, regional environment, social relations with the landscape, the differences between preserved and degraded environments, responsibility for environmental quality, the alternative to harmonize human action and its environmental impacts.

The Brazil higher education institutions are responsible for the training of professionals, researchers, technicians, teachers, and in more specific areas of knowledge. Therefore, the education that emphasizes the study of environmental issues and encourages research and extension to solve problems, whether local or global, is essential for proper undergraduate level. In this sense, all courses should incorporate environmental issues in university education, encouraging dialogue between diverse areas of knowledge, encouraging teachers and students to know and research the reality of the environment where they live.

Thus it becomes clear, the legal necessity of including specific disciplines such as in the scope of environment in the curriculum or extension of the basic curriculum related to environmental issues as claimed by official documents and national and international guidelines.

3.1.3 Proposed actions

The inclusion of disciplines related to water resources allows for changing values, habits and attitudes, thus leading to a growing awareness of environmental problems on the planet to ensure a healthy environment for all (Tozoni-Reis, 2004).

Addressing the environmental problems today requires that education is a mediator of human activity, linking theory and practice. The role of environmental education in the context of water resources undoubtedly permeates all areas of knowledge and thus includes environmental issues. It is necessary to strengthen the integration of environmental education in political pedagogical project at schools (from primary school to postgraduate) in an interdisciplinary manner, as a collective plan of school and academic community. In this context, higher education should not ignore environmental education, either as a cross-cutting theme regarding courses and disciplines, or as specific discipline when needed for training of teachers or professionals responsible for developing research and extension projects.

In addition to the inclusion of topics related to water resources in the curriculum evolved there are many factors and obstacles that must be overcome, among which are the different conceptions in dispute in Education (Traditional/emancipatory), lack of understanding of the concepts of interdisciplinarity and transversal (which possibly were not part of the training of those who today develop teaching activities). These factors largely impede the questioning of reality and do not favour the discussion of contemporary social issues. Rather, they reaffirm simplistic approaches and sidewalks in biology, or do not allow changes to education, hindering the formation of critical educators and the ability to cope with the challenges imposed at different levels and modalities of education.

Finally, it can be stated that regardless of education level or educational background, whether in school or outside environment, environmental education especially the one related to water resources, either by establishing dialogue about the relationship between society and the environment or the changing patterns and behaviors that it requires, is an essential component to the transformations that can be given by the education, as reviewing ways of acting and thinking in relation to the nature, assume a new position, individual and collective, consistent and harmonious with the environment in which we live.

3.1.4 Environmental education directed to water resources

Indeed, issues related to water, such as water resources, watersheds and water sources have been strongly highlighted by historic preservationist and conservationist movement, even up till today, has taken prominent position when it comes to discussion or proposal of policies relating to environmental protection (Sutherland et al., 2006, 2009). In this context, it is interesting to note that, although recently called greening of the society with the development of practices called environmental education, research and extension activities that include actions directed at the topic has become increasingly present and consistent among research projects in agricultural and environmental sciences.

The tendency of proposing the watershed as a reference point for analysis of aspects related to water or water resources constitutes a significant advance, since it is proposed to discuss

the problems related to water resources in the spatial scale at which they operate the degradation factors. For instance, how soil conservation and riparian forests, expand the reach of environmental education programs. As proposed by Bacci & Pataca (2008), working in the context of watersheds allows the articulation between natural and historical, from which one can create learning situations and provides an understanding of the interrelated processes in the environment.

Considering the watershed as a unit of analysis also allows the students or learners to put in close contact with various actors and social sectors, which are responsible for the processes of water management. Experience of this type can help those involved in the education process have better dimension of the need to integrate efforts and implement effective measures to mitigate environmental impacts or to find solutions for problems related to the preservation of water conservation.

The contact with different agents and different community groups leads us to consider that dialogue of knowledge in the management of environmental issues is needed. We emphasize the importance of interdisciplinarity in curriculum and content development during classes. This interdisciplinary perspective does not dilute the disciplines rather, it maintains its individuality. Also, it integrates the disciplines from the understanding of the multiple causes or factors that intervene on reality and all works necessary for the formation of knowledge, communication and negotiation of significant ideas and systematic recording of results (BRAZIL, 2002).

Regarding the universities, it is emphasized the need to accept the challenge of implementing a curriculum geared to water problems or environmental problems which either means assume part of the responsibility in the intellectual formation of society, consolidating the formation of an environmentally conscious society. However, boldness, breaking tradition and intellectual conformism, as well as stimulation of theoretical, conceptual, methodological, and curricular innovations are required. Breaking up with such secular changes in routines implies and requires an open, flexible educator, aware of their social role and not a mere player of positivist practices.

3.2 Case study of curriculum analysis

For the universities assisted by ALFA program to be able to effectively promote and improve the training of professional graduates of their preferred courses, there is the need for a profound analysis about the curriculum, especially those disciplines closely related to management of water resources and environment.

From there, it will be possible to reshape and build a curriculum guidelines guided by the needs and principles promulgated by environmental sciences, which aimed at sustainable use and management of natural resources. It is also stressed the need to include professors with research lines related to these areas so that the knowledge will spread effectively through extra-curricular activities and research by inserting and integrating the academic activities with the development of applied research, mainly the social and regional needs.

However, for this project to be implemented, it is necessary to make a thorough diagnosis of the aspects related to the teaching of the core subjects and curriculum related to the

handling and management of water resources and environment. Thus, this study aimed to diagnose and assess the current state of the curriculum base of Agronomy and Forestry Engineering courses of the Federal University of Santa Maria, Brazil in order to implement and improve the training of professional graduates of these courses in areas related to natural resource management.

3.2.1 Material and Methods

Interviews were conducted with the coordinators and professors of Agronomy and Forestry Engineering, selected undergraduate students who were either at the beginning or the end of their major, and graduates of these majors who are currently studying at masters and doctorate levels in Soil Science and Forestry Engineering, in the Federal University of Santa Maria, Santa Maria, Brazil, as well as professors from other national institutions, engineers from State Agency for Technical Assistance and Rural Extension, and professionals from the private sector of companies related to forest exploration and environmental conservation in 2013 (Table 1).

The interview was administered with the aid of structured questionnaire as:

1. Does the training of Forestry Engineering or Agronomy students meets the professional needs required in the field of water resources and environmental management?

2. How do the curriculum lines and disciplines meet this need?

3. What are the minimum contents or subjects that should be included in the curriculum to meet this requirement? Do you have any suggestion?

After data collection, the responses were compiled and the results were analyzed.

Table 1: Detailing of classes interviewed in Santa Maria, Brazil, 2013.

Description of class interviewed	*Number of interviewees*
Undergraduates courses coordinators	*2*
Professors from Federal University of Santa Maria	*9*
Professors from other national institutions	*8*
Undergraduate students	*8*
Post-graduation students	*15*
Engineers from State Agency for Technical Assistance and Rural Extension	*5*
Professionals from the private sector	*5*
Total number interviewees	*52*

3.2.2 Results and discussion

3.2.2.1 Analysis of Forestry Engineering curriculum

The professional training of Forestry Engineering major of the Federal University of Santa Maria does not fully attend the professional needs related to water and environmental resources. Professors and students at bachelor's, masters' and doctoral level unanimously expressed this view.

The lack of integration between disciplines creates a fragmented vision. It is observed that some curricula seek to meet the political and business interests. This occurs due the historical context of creation of the course, where the demands were aimed at forest production with fast growing exotic species. Regarding the recent context of environmental demands, in general, it is not integrated with other disciplines. However, the training meets with the specifications established by the Regional Council of Engineering, Architecture and Agronomy (CREA).

Concerning the undergraduate course in Forestry, the discipline related to water resources is called "River Basin Management"; however, it does not provide full understanding on the theme, being focused in the control of erosion, especially regarding the hydrologic cycle that controls such processes. Thus, it is necessary to be taught the basic subjects that are directly related to water resources, their functions, importance and methods of conservation as prerequisites.

The Forestry professionals could identify, manage and study the phytosociology of riverine species. However, disciplines such as hydrology and transport phenomena are missing in the curriculum. This creates a gap in the topics related to forest hydrology and river basin management, thereby creating a knowledge gap in water resources

The curriculum, as part of the pedagogical project of courses, seeks to correlate water and environmental resources in the context of the specificity of each one of the disciplines offered by the Forestry course for professional training.

The practical aspects of the courses should be adjusted to address issues involving environmental resources in agro-forest activities. Thus, the curricular guidelines should be inclusive and not conditioned by the demands which organizations determine in order to make the fieldwork broader.

The Forestry major at the Federal University of Santa Maria is adapting to new trends and trying to train professionals with a view to meeting the knowledge gap in water resources. In this context, the curricular guidelines must be integrated, seeking together the acquaintance of knowledge on natural resources, encompassing the knowledge related to native flora and fauna, water resources and maintenance of areas, either by soil management or by understanding the processes that occurs in the ecosystems.

The courses must include topics related to the four areas of knowledge mentioned. In order to improve the curriculum, the number of subjects (disciplines) could be reduced and the workload increased, including more than one professor per subject. This is aimed at

integrating the subjects (agglutinating factor), because the environmental topics are not presented and organized in an articulate manner.

However, besides the curricular improvement and adaptation, it is necessary to disclose the activities performed and the areas of expertise of the Forestry Engineering, in order to develop the work integration aimed at the conservation and maintenance of the environment and water resources. As an example, by reporting that some cities in the state of Rio Grande do Sul (Brazil) often suffered from long droughts, it is observed the need for understanding the whole hydrological cycle in order to evaluate and overcome the effects of such occurrence in a sustainable manner.

The disciplines that should comprise the minimum curriculum of the Forestry major should be integrated and related to the ability to manage ecosystems. The central topics must be: native forests, water resources, soil, and fauna. There is a need to change the existing disciplines by adding and updating the contents within each discipline, as it is observed the difficulty of students in associating the contents taught in different disciplines and associated disciplines.

The studies developed under the native forests are very superficial; emphasizing studies with the development of species and the possibility for sustainable use of exploitation of forest products, such as those species with potential for fruit production. The soil resource should be approached with greater intensity, especially on soil classification and quality indicators, phytoremediation and management and restoration of degraded areas. The focus of the disciplines of wildlife should be extended; the curriculum currently incorporates only one specific discipline of wildlife, which is rich and diverse, especially in native forests.

Thus, environmental issues should be treated in a multidisciplinary, interdisciplinary and transdisciplinary manner. This means that the contents related to water and environmental resources should be part of the knowledge acquired by future professionals. For all studies and subjects, it is important to approach topics having as the basic unit the river basin, because of its environmental importance and the associated elements. Thus, it will be possible to explore extensively the knowledge on water resources through the development of projects for different ecosystems, in accordance with current legislation.

Subjects related to water resources, currently appearing in the curriculum of Forestry course are: Hydrology; River Basin Management; Environmental Licensing and Assessment; Environmental Policy and Legislation; and Forest Ecology. However, there is an evident lack of basic and fundamental disciplines such as: Applied Hydrology; GIS applied to Water Resources; Water Resources Management; Water, Soil, Plant and Atmosphere Interactions; Meteorology and Climatology; Hydrogeology; and River Basin Management, with a focus on the appropriate land use and understanding of the hydrological cycle through water balance for the different systems.

3.2.2.2 Analysis of Agronomy curriculum

According to some professors of Agronomy major of the Federal University of Santa Maria, the professional training in Agronomy must have a high level of knowledge on water resources, mainly due to its great importance for agriculture and environmental conservation.

However, it is a common consensus that the current graduate students of Agronomy from the University do not attend all professional basic requisites related to the handling and managing water resources and the environment.

This is a direct consequence of the current curriculum, which is not unified and does not follow the interdisciplinary basis, which aims to integrate knowledge from different scientific fields. The interdisciplinary is an important integrating agent of contents, being able to help on the comprehension of students (future professionals) on issues related to environmental conservation that, based on the current curriculum, are divided into various disciplines. This, according to the professors, is a major problem for the socialization of knowledge among the students; hence it hinders the overview of information from the different fields of science.

The Engineers from State Agency for Technical Assistance and Rural Extension opined that the curriculum, despite the recent reforms, was based on a guideline historically focused on productivity and the development and production of crops, during a period where the social and governmental pressure for the preservation of the environment was insignificant. Thus, assignments, such as the preservation of the environment and natural resources were not relevant or focus of the performance of Agronomist. Among the changes, we can mention the inclusion of the Internship and Seminars in Agronomy, which are aimed at promoting the interdisciplinary relation and the integration of knowledge areas. Thus, the professional training in Agronomy partially meets the professionals needs related to the management of environmental and water resources.

According to the undergraduate and graduate students of Agronomy, the knowledge acquired on water resources is considered insufficient, confirming the opinion of professors. However, it is emphasized that the environmental issue is addressed constantly and increasingly in the course; especially due to the recent growth of public awareness with natural resources; however, the environmental concern with water resources, in particular, is incipient and needs more attention.

Thus, it is by common consent among students interviewed that the training of Agronomist in this particular case (at the Federal University of Santa Maria) may not meet all requirements that the professionals need to properly conduct their work and activities in the field of water resources and natural sciences. Therefore, it is emphasized the need to include professors with lines of research directed to these areas in order to gain the necessary knowledge to expand extracurricular activities, inserting and integrating teaching activities, with the development of researches mainly directed to the regional needs.

The teachers interviewed add that, as mentioned previously, the formation of Agronomists needs improvements in relation to environmental issues. Thus, the curriculum of Agronomy major could count on more subjects that address this issue, because of its complexity and fundamental importance to the student's formation. Furthermore, when studying watersheds as a management unit, to understand the environmental factors on water resources is essential, based on principles that, within a river basin, planning can be made for the conservation of natural resources and restoration of areas degraded.

Subjects to be implemented in the curriculum of the Agronomy course, as mandatory or option were suggested: Environmental Impact Assessment; Hydrology; Water Resources;

and River Basin Management. With these subjects students could acquire more knowledge and enhance their understanding on preservation and proper use of natural resources.

3.3 Conclusions

To foster and develop environmental awareness among new graduates, it is essential to strengthen the foundations of current curriculum. This conclusion was endorsed by the opinions of students, teachers and professionals who participated in this study, which ratified the need for the reformulation of curricular base of Agronomy and Forestry Engineering majors. This can be achieved with the introduction of new disciplines and/or a readjustment of the workload of existing disciplines, especially those related to water resources and environmental management.

In addition, the curriculum should be improved and rebuilt, considering the interdisciplinary principles, with a view to enabling the integration of knowledge between different areas of specialization. This reformulation is decisive, facilitating student understanding, that through interdisciplinary vision aggregates the content and issues related to environmental preservation and conservation, thereby consolidating their training from the full view of information from different fields of science.

It is emphasized that it is essential to enter activities that would enable students the integration between theoretical and practical knowledge, provide opportunities for investigative and reflective learning. However, for this to be realized, it is essential the intensification of the interaction between the university and environment where it operates, by actively participating in the production of industrial, economic and social development.

3.4 Final considerations

Based on the considerations presented, it becomes necessary a reformulation of new curricula for Agronomy and Forestry Engineering disciplines with a view to producing professionals who would be able to meet the professional needs related to environmental sciences.

Among the key actions to be implemented:

- redesign and rebuild a multidisciplinary curriculum guided by guidelines focused on the needs and principles promulgated by environmental sciences with emphasis on the sustainable use and management of natural resources;
- include professors with research topics related to water and environmental resources management;
- expand the horizon of students' education with extension activities and research;
- increase the number of projects between university-enterprise cooperation, encouraging students' participation and overlooking the application of acquired knowledge in professional practice;
- integrate teaching activities with the development of applied research mainly to social and regional needs.

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Part 4

4 University and Private Sector Partnership to Improve Practical Training in Water Resources: A Case Study in Latin American and European Universities

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4.1 Introduction

In an increasingly globalized world where knowledge and information evolve and spread at a rapid pace, the idea of academic space has assume new dimension, extending far beyond the geographical or linguistic boundaries, making mandatory international cooperation and bilateral agreement between universities (Etzkowitz et al., 2000).

Collaboration among national universities in different states or foreign universities, with distinct social, technological, cultural and educational realities, forms part of the global strategy that seek excellence in academic performance by eliminating deficiencies and overcoming the inequalities and imbalance between people and nations (Altbach; Knight, 2007).

4.1.1 Cooperation among national and foreign universities

In recent decades, the internationalization of universities has become an important factor for institutional classification and therefore one of the priority goals of its strategic planning. This internationalization of higher education emerged mainly due to three main factors: as a response to the phenomenon of globalization; as possibility of ensuring the quality of human resources, infrastructure and actions; and as a way to strengthening the teaching, research and extension programs of universities establishing research networks, promoting the exchange of knowledge (Etzkowitz et al., 2000).

Therefore, to carry out the process of internationalization and institutional cooperation, universities should seek to develop projects and action plans aimed at increasing partnerships with both national and other universities in various parts of the world, thus spreading the image of a contemporary and dynamic university prepared to interact with other people and cultures in the pursuit of progress and development of its faculty and students (Altbach; Knight, 2007).

The insertion in international cooperation networks facilitates the expansion of range of contacts and multiplies the possibilities of inter-institutional relations, giving strong impetus to

the signing of international cooperation and bilateral agreements (Chan, 2004). In this context, bilateral agreements with national or foreign institutional counterparts make possible the realization of numerous activities in partnership benefiting the institutions involved (Van Damme, 2001).

The agreements ensure the realization of activities in a varied manner, which affirm the mutual interest of the signatory institutions effectively. Such activities include promotion of student exchange programs with diverse objectives; mobility of visiting professors and researchers; joint publications, seminars, lectures, conferences-international activities which bring together renowned scientists, organization of study tours and techno-scientific visits; and development of joint research projects with the objective of finding resources for funding and technical visits to meet potential new partners for the realization of the new collaborative work (Etzkowitz et al., 2000).

International cooperation and bilateral agreements drive international projection and visibility, enabling rapid closeness between researchers, which in turn stimulates the presence of the institution in the joint research programs, and increase the chance of getting funds from international sources and funding agencies as well as financiers of research projects with funds from government agencies (Chan, 2004).

All these external actions and national and international transit gear the universities to develop their academic mobility programs at both undergraduate and postgraduate level. Thus, teachers, researchers, students and administrators can participate in the national and international experiences from participating institutions of the cooperation programs. Recently in Brazil, some government programs have increased the possibility, especially for graduate students, to undergo studies in other Brazilian or foreign institutions.

One of the most obvious results of these programs, especially at the undergraduate level, is the training of qualified citizens to serve the global market alongside the development of global competencies. At graduate level, the emphasis is on making international modules to strengthen and widen the knowledge already acquired.

4.1.2 Cooperation among universities and companies

Besides the relationship between higher education institutions, it has become possible and indispensable the implementation of actions of university-industrial cooperation, which has raised the productivity and competitiveness of firms in the past decade in the face of fierce international competition and acceleration of technological change in various sectors of the economy (Fritsch; Schwirten, 2009).

The university-industry interaction brings benefits for both the company and university since the mission of the university is to train human resources who will generate quality knowledge to the society, by performing basic and applied research to improve knowledge. Since the attainment of knowledge and research are considered key elements for better development of individuals, such that the industries seeking "profits and better productivity", known as growth indices, may have qualified professionals produced by the university, who can generate innovative products (Fritsch; Schwirten, 2009).

The university-industrial cooperation appears as a tool to leverage technological development and diffusion of innovations, particularly for small and medium enterprises (Fujisue, 1998). The ability to innovate depends on the realization of scientific research and requires able human resources to generate and transmit new knowledge.

Universities are key institutions for the continuous search for innovation as they have accumulated knowledge and skilled manpower. According to Etzkowitz et al. (2000), to make the university take a new direction, research is ideal, as it will contribute to significant changes in the society. Thus, the university develops technological research by prioritizing the training of qualified human resources. Thus, industries constitute productive sector with better technological perspective and an environment composed of skilled and more competitive professionals.

Improved institutional cooperation between the universities, authorities and private sector would be achieved by initiating round tables to discuss legal aspects, development of guidelines and technical norms (Van Damme, 2001). The lack of practical orientation of higher education has to be overcome.

Therefore, it is necessary to know primarily the practical activities developed in the partner institutions, in order to establish and develop structures for institutional cooperation between universities and public authorities/private enterprises (Etzkowitz et al., 2000). Most important is to establish sustainable structures; it means to work out a concept that ensures a long-term collaboration. Both sides have to be convinced of the advantages of better cooperation.

This study aimed to highlight the main projects and actions of institutional cooperation implemented by Latin American and European universities, and point out the management actions and projects that could facilitate or increase the effectiveness of cooperation activities in their respective universities.

4.2 Materials and Methods

The subjects of this study were teachers from CapWEM's partner universities.

Structured questionnaire was sent to each of the representative universities who responded in accordance with the reality of his or her respective university. The interview was administered using the following structured questions:

I. How does your higher education institution (HEI) provide and/or encourage practical activities for students, in order to apply the theoretical knowledge assimilated during their respective courses?
II. Concerning the practical issues mentioned before. Please, respond to the following questions:
    a. Does your HEI establish curricular internships (intra and extra)? If so, how are they arranged?
    b. What is the main sector selected for students to conduct internships (public or private)?
    c. Does your HEI support internships abroad? If so, how?

d. How are they organized at your HEI the different practical issues (internships, monitoring, scientific initiations, study visits and field works, events and seminars planning, junior enterprisers, learning tutorial groups, extension courses, complementary disciplines)

III. In your opinion, how does the institutional cooperation related to practical issues in study programs can be improved? Are there any new practical programs and activities to be implemented at your HEI?

IV. Despite their usefulness as teaching tools, practical activities, such as field work and study visits, are threatened due to many factors, not least health and safety issues, increasing student numbers and financial costs. In order to ensure student learning, by integrated into the curriculum those activities, what are the tasks and learning outcomes observed by your HEI?

After data collection, the responses were compiled and the results were analyzed and discussed.

4.3 Results and discussion

4.3.1 Measures to encourage practical activities and programs for students to apply the knowledge assimilated

Practical activities and programs are compulsory for the gradual assumption of professional role, through the insertion into a specific work environment, which will enable the integrated application of knowledge gained throughout individual career. These activities and programs should be included in the curricula. Courses should include practical assignments, field trip, workshops, seminars, lectures from experts (companies/public institutions) and others. All practical activities should be supervised by professors or assigned staff.

In addition, lectures should be supported by work in the laboratory depending on the corresponding module of the study course plan. Excursions to related sites and on current relevant topics should be offered as well.

Internship in private and government enterprises should be mandatory in the final stage of the career and there should be a link supports for students for working agreements with private companies or public institutions.

The promotion and stability in time of practical activities occur mainly by granting of scholarships or grants, therefore, funding should be made available by the institution through the government at all levels and private entities.

4.3.2 Practical issues

4.3.2.1 Internships

The aim is to enable students develop their theoretical knowledge in the professional career and labor market. Internship program should be mandatory and free for all students. Whether it is done within or outside the institution of study, there should be proper monitoring and supervision by both the university and private/public organizations. It should also have a record of the activities performed and evaluated by one or two supervisors and credits should be given so that it will reflect at the end of the program. This will enable them to be more attractive and as an evidence of special skills.

In the case of students accepted by private organizations or outside the country, by exchange program or otherwise, the institution should ensure that issues relating to scholarship, funding and proper monitoring are maintained to ensure the student gets the best result and the objective is achieved.

4.3.2.2 Monitoring

Monitoring is a vehicle for understanding how students are progressing toward established goals; creating opportunities for class-, school-, and/or district-wide screening to identify students potentially at risk for academic failure; and offering data that can provide accountability evidence to parents, teachers, and educators about the impact of intervention programs.

To ensure proper monitoring, activities are organized and managed by the professors and technical staff. In special cases, Teaching Assistants/Graduate Assistants, who are good academically and competent, could be employed to assist in correcting home works, arrange and supervise practical classes, organize laboratories and coordinate field work and excursions. They should ensure reports are forwarded to the unit head for evaluation on weekly or monthly basis. They should be thoroughly motivated and remunerated through scholarship or otherwise.

4.3.2.3 Scientific initiations

This is a fundamental aspect in scientific production. Students, at all levels, should be exposed to the basics of research and scientific process. They should undertake all aspects of academic research such as literature review, research design, practical development, technical writing and presentation of results for publications and at scientific events. Professors and specialists, both in the institutions and public/private organizations should make available opportunities for scientific initiation in several areas of research.

In addition to integrate the scientific initiation into the school programs, a major incentive and motivation is the possibility of obtaining grants.

4.3.2.4 Study visits and field works

These are activities organized in the respective disciplines and courses to ensure a thorough understating of the theoretical aspects and to be able to compare various scenarios. This can be in form of a tour related to their scientific interest or planned under a certain research project or a practical activity to the development of discipline. In most cases, publics and private enterprises are involved; hence, both parties require adequate planning and proper cooperation.

All logistics relating to adequate funding and organization should be put in place. Students should be made to submit a comprehensive report after each visit or field work. These reports should be thoroughly evaluated and assessed so as to ascertain areas of deficiency.

4.3.2.5 Seminars and events planning

In order to further enhance the scientific initiation of the students, stimulate the ability to speak in public and freely express their findings and evaluation of practical activities, study visits, field work, etc., seminars and workshops should be organized by the department or unit. There should be standard organization and structure for these and should carry unit/credit for assessment.

Attendance and adequate participation by students at all levels should be ensured. To ensure strict compliance, penalty should be put in place depending on the severity.

Professors could organize seminars, workshops or academic events related to their scientific interest, subject to a funding or sponsored projects. These should seek to address current issues of scientific, social economic and environmental relevance.

4.3.2.6 Learning and tutorial groups

The importance of learning and tutorial groups in students' academic pursuit cannot be over-emphasized. It should be an avenue when created to inform, assist and guide students in their concerns, doubts and difficulties with the career and will go a long way to preventing the abandonment of the career. Teaching/graduate assistants should be assigned as tutors/coordinators. There should be room for discussion and analyses of laboratory and field procedures and results.

For each learning/tutorial group, professors and other technical staff should be assigned to provide more guidance and counseling. Students should be readily available or assigned meeting period for compliance. For special cases, students can make personal consultation.

4.3.2.7 Extension courses

Extension courses are those that are targeted towards the society. The overall aim is to study the various techniques of gathering and disseminating information to and educating the populace on new discoveries, innovations, inherent dangers and preventions especially on issues related to the environment, human resource management, among others.

These courses should be included in the curriculum, especially in this area of Water Engineering and Environmental Management. They should encompass strong practical components, that is, demonstration fields and extension villages should be provided, and community participation is paramount. Seminars, workshops and training courses should be integrated by these courses.

4.3.2.8 Junior enterprises

The purpose is to encourage the integration of university graduates in the promotion of the entrepreneur spirit among students and to strength ties between them and the marketplace by providing “learning by doing” experience for students, connecting academic knowledge and the business world, fostering entrepreneurial skills, enhancing employability in a local market and improving local economic and social growth.

Students of Junior Enterprises should be able to render the following consultancy services to companies and other organizations:

- Developing business plans
- Building up marketing strategies
- Doing marketing research
- Consulting engineering projects

Besides these types of consultancy services for others, the Junior Enterprises should be able to develop their own projects like:

- Building start-ups
- Organizing workshops and conferences
- Organizing assessment centers
- Quality management projects
- Knowledge platforms solutions

These activities should be under the guidance of teachers and professionals with the goal to consolidate and enhance the learning or their members.

4.3.2.9 Complementary Disciplines

In order to have basic knowledge in other disciplines that are directly or indirectly related to the student course of study and understand the interrelationship and to help the students develop as better professionals in the future, it is imperative that all students register two or more extracurricular courses, depending on the curriculum.

While these courses are part of student assessment in some systems, in others they are required to graduation. To ensure students devote interest and effort, the courses should be part of the continuous assessment and they should be given the option to choose a given number of such courses.

4.3.3 Institutional cooperation, programs and activities related to practical issues

Since most institutes of higher learning do not have the financial capacity and an effective and realistic way of increasing and maintaining the practical component in a sustainable manner, there is the need therefore to increase the cooperation and collaboration between the entrepreneurial world and the education/research centers.

Programs are needed that will develop the collaborations and partnerships with local, state and federal government, universities, research bodies, civil societies and non-governmental organizations (NGOs), among others, to promote shared management actions and inclusion of students in the society and greater participation of university in the social aspect.

These projects must involve partners in the public and private spheres, universities for techno-scientific exchange as well as the development of new scientific and multidisciplinary studies in diverse areas of knowledge, and include partners in the communities for the development of voluntary services and local industries, enabling for the partners the conditions for events, meetings and outreach activities in conformity with the objectives of program of cooperation in question and to promote interaction between agents, universities and students.

4.4 Concluding remarks: Suggested “best practices”

Based on the findings observed and described in this research, we propose a list of “Best Practices” necessary to implement programs or collaborative partnerships between universities and other public institutions, research institutes, non-governmental organizations (NGOs), among others.

Among the primordial actions to be implemented are the:

- development of programs to promote the inclusion of students in the society and increased involvement of the university in the social aspect to enhance the interaction between agents, universities and students;
- internationalization of university activity by creating a specific body to ensure the strengthening and implementation of new activities and agreements with educational institutions, research institutes, companies and other countries;
- expansion of cooperation opportunities, vacancies and agreements between the institution and other universities, companies and NGOs or foreign nationals;
- establishment of measures to stimulate the student internships, dissertations and theses in cooperation with companies and institutions other than the university;
- enactment of a system for financial and logistical support to students of other nations aimed at facilitating exchange of researchers and students;
- establishment of a unified international standard that promotes the migration of students between educational institutions and which permits the use of the disciplines and activities from foreign institutions.

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Part 5

5 Linkage between the University and Industry: Opportunity to promote Innovation and professional Formation

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5.1 Introduction

A nation's competiveness depends on the ability of its industry to innovate and improve. In fact, companies gain competitive advantage through innovation, this being the product of the interaction between public policy and the resources provided by the state to foment new knowledge and apply it to the productive systems. In this complex arrangement it is essential to be aware of the levels of linkage that exist between the source of new knowledge and the industries that apply and use it in the development of their productive processes. Companies and Universities are entities that possess specific characteristics, an operating rationale, objectives and organizational models that substantially differentiate their proceedings.

In developing projects for Innovation, Development, Research and Transfer (I+D+R+T), and their related businesses, two important elements are distinguished. On one hand are found the universities as agents of knowledge creation by means of Research and Development (R+D), and likewise, its dissemination and transfer through the education of professionals and linkage with the environs. On the other hand, there are the companies that use said knowledge and apply it to their traditional activity, or else create their own knowledge through applied research and development. Currently, the dynamic model for technology transfer is based on the Triple Helix concept proposed by Etzkowitz et al. in the mid-nineties. This model proposes an integral relationship among the main actors in economic development and innovation: 1) Academia, 2) industry and 3) Government with each playing a predominant role in the realization of new projects and innovations, as well as the development of professional and technical capabilities.

5.2 University – Industry Linkage

In the last twenty years, the University – Business Linkage has undergone a profound paradigm shift, moving from a distrustful relationship to one of a synergetic nature. Currently, the university and the business world are maintaining fluid relations that facilitate the exchange of experience and knowledge, thus contributing to the diffusion of technology, the

development of new initiatives, and knowledge and innovation management. In this manner, both institutions have found the road to making fruitful and permanent ties.

With the advent of the new millennium, the linkage has moved toward a symbiotic relationship in which common purposes are expressed bi-directionally. Collaboration with the university provides industry with various kinds of benefits. For their part, the universities revalue the work of industry, providing it with a source of highly educated creative talent that is a primary requirement for the long-term success of any company that depends on knowledge generation.

Likewise, when collaborating with universities, companies gain reduced transfer time for marketing the research results and, at the same time, improve their image. The University/Industry Relationship can be promoted either formally (for example, research partnerships and research contracts) or informally (conferences, courses and seminars, among others). In the former case, an arena or degree of greater linkage is implied making possible mid or long-term agreements in terms of their common results oriented objectives.

Of whatever type the relationship may be, it is important to not lose sight of the need for the Business/University linkage to focus on Technology Innovation Management understood as the organization and administration of both human and economic resources in order to enhance new knowledge creation, technical idea generation, which makes possible obtaining new products, processes and services, or at least improving those already existing.

The innovation dynamic, as well as the development of new scientific-technological capabilities and the seeking of opportunities from new technological paradigms relate not only to investment in research and development and in human resources (determining factors in the potential inclusion of knowledge in new products, services and processes), but also to the institutions (companies, universities, research centers, public sector and civil society) and institutional networks than give support to innovation and that can affect its direction. The interaction among these variables is fundamental to the learning patterns that are specific to different countries and sectors.

It is without doubt that the universities perform a fundamental role in the creation of knowledge and in the development process of countries. Throughout history, simultaneously with scientific and technological advancement universities have undergone a great evolution both in their objectives and in their organization and their relations with other social institutions and agents. Thus, over these stages of development the university has been significantly changing and the original institution is being radically transformed as it progressively adds to its more traditional mission the newer and more sophisticated functions coherent with the changes in the economic structure and in the modern society, converting the university into one of the principal agents of both social and economic change.

The transition toward a knowledge based economy and society has brought about profound transformations in the productive structure, likewise modifying relations among the various agents that has involved redefining the work of higher education institutions. The challenges associated with the new productive models that revolve around knowledge, technology and innovation require that the university rethink and remodel its characteristics in order to continue being a fundamental pillar of economic development in the country.

Therefore, the ability of a company to innovate is strengthened by establishing relations with other firms and institutions that makes possible sharing accumulated knowledge while reducing the costs and risks related to innovation activities. Even though there are many types of cooperation depending on with whom it is set up (which may be another firm, a university or a government office), or depending on its purpose (such as incremental innovation, radical innovation, innovation in products or processes, among others), the evident result is that no matter the type, cooperation with always rise as a positive innovation determinant.

Universities and industry are principal actors in the innovation process and both have the fundamental scientific and technological ability and capacity for generating knowledge, which frequently turn out to be complementary. Creating links between universities and industry should be developed according to the idea of complementary specialization: generating and strengthening the convergent elements between them, that is, their respective scientific and technological capacities and, at the same time, diminishing the divergent elements without eliminating the particularities, objectives or mission of either one. The differences between the university and industry are also expressed in the diverse purposes that motivate establishing the linkage between them. The main reasons that drive universities to establish a relationship with industry are related to the traditional mission of higher education institutions, that is, to educate and to do research.

As for industry, the drive to develop a relationship with a university or research center is mainly based on that which is practical and economically convenient. In the first place, many companies turn to universities or research centers looking for specific and short-term relationships in order to solve explicit production problems or reduce supervision or scientific development costs. Moreover, these relationships can contribute to overcoming the technological lack in the private sector in terms of infrastructure for research in science and technology. In fact, through the use of external capabilities, such as the equipment and the qualified human capital in universities, a company can reduce the resources, the space and costs associated with carrying out internal research and development in the laboratory.

Those companies that aspire to bringing about a competitive strategy directed toward obtaining and implementing scientific knowledge to convert themselves into innovative companies, need to not only make use of existing knowledge, but also, generate new knowledge which requires and even greater effort in order to develop and strengthen their internal scientific-technological capabilities. This, in turn, implies that the innovating companies have to rely more and more on the knowledge and resources produced by universities and research centers. Thus, performing proactively and developing strong ties with the world of science and technology is an answer to the demand for strengthening potential stable, long-term competitive advantages.

5.3 Feedback for curricular improvement

In the matter of advanced education of human capital, to meet the needs of the production sector, universities are the best links for industry and public institutions. Regarding this, and as part of the methodology used to discover what was needed by the companies in terms of professionals in the area of Water and Environmental Management, a workshop was carried

out with representatives of the public and private sector. There were several participants from governmental institutions, e.g. the Ministry of Environment and the Ministry of Public Works. Furthermore representatives of other public institutions like the National Institute for Agricultural Research and the National Commission for Irrigation took part. Finally members of the University of Talca represented the academic area. The workshop aimed at finding out exactly what competencies professionals in the related engineering areas require. It was organized in working groups and a plenary session at the end to discuss the contributions.

Results indicate that the competencies required in the education of human capital in the areas of Water Engineering and Environmental Management in Chile include participative, methodological, and technical skills. The competency that should receive greater emphasis was that of coordination, given that, according to the workshop participants, there is a lack of institutional communication and coordination skill that impedes proper teamwork, a limited vision of the sector that excludes other sectors, and excessively individualist professionals. To improve the ability to coordinate, creating incentives for developing teamwork and promoting relationships with other sectors were proposed.

Considering the input from the professionals, their analytical ability was seen as limited due to the fact that there is currently a low level of reading comprehension among students and professionals, which is added to an overly rigid educational design. To improve this aspect, educational processes should focus on problem solving (work based on case studies) and the educational system should have a more practical orientation. The ability to suggest solutions is another area to improve, the cause of which is rooted in the development of an overly rigid educational design and a very passive student-teacher relationship.

Some measures for resolving this issue include establishing a knowledge dialogue where both the teacher and the students receive feed off of each other’s experience, and improving the methodology for analyzing problems and finding solutions. Related to the ability to coordinate, it was considered relevant to develop teamwork skills, which was also evaluated as low because of the individualist and highly specialized focus of some programs of study. To improve this situation, it was suggested to develop activities among the students in related programs, through theoretical-practical assignments, taking introductory courses complementary to the area of specialization and promoting exchanges among students in the various disciplines.

Mastery of basic skills is low, primarily due to lack of depth of content, especially in the “hard” areas, in the university curriculum. A proposed solution is to explicitly require the practical application of theoretical knowledge and promote continuous learning. The workshop participants indicated that the capacity for innovation in our country is low because of low motivation and development potential, rigid education, adversity to change, fear of failure and the lack of knowledge and opportunities. To improve this situation it was suggested to create incentives for innovation in education, make changes in standards, improve articulation among the areas, have greater professional development, implement more flexible curricula and better financing.

The strategic vision of students and professionals is low due to the compartmentalization of knowledge, shortage of curricular content and lack of a general overview of the problems.

Some measures for dealing with the issue include developing case studies as part of the education, greater methodological development, give incentive to a focus encompassing several areas, incorporate a strategic vision into educational plans and verify government commitment. Finally, it was rare to find continuous improvement models being implemented because low standards, lack of incentives, a high degree of resignation, and little adapting to change. To improve this reality, it was suggested to modify the standards, generate incentives, set up formal professional development activities and improve training methods.

The workshop participants identified 6 topics and 34 relevant courses that could be included in a program of studies for Water Engineering and Environmental Management. The topics that received greatest support were Hydrology and Modeling, Management of Water Resources and Applied Hydrology. Climate Change, Ecosystem Management and Erosion and Sedimentation followed these. The results indicated a clear orientation to topics related to water management. Consequently, the participants proposed modifying the focus of the current programs to Environmental Water Management in order to emphasize the water resource and its management in environmental terms.

5.4 Final words

The legitimacy and validity of the universities as institutions fundamental to the development of countries and geographic realities, lead to taking on a vital and repeated commitment to the different agents that interact in the regions they cohabit. In a globalized world embedded in a dynamic of constant change, the universities are transformed into principal players that permeate into the local, regional and national societies.

Universities must continuously strengthen the links with their surroundings, avoiding falling into a false sense of a self-sufficiency that excludes outsiders. In the knowledge society, linkage with the surroundings means being highly involved in the education of people (human capital) and the creation of knowledge. Nonetheless, the universities must keep in mind that they neither have a monopoly on nor represent the exclusive place for the generation of specialized knowledge. As of several decades ago, industry and the public sector have taken on leadership roles in applied and advanced research. This is a fact that modern universities have understood for a while, developing strategic and cooperative alliances built out of mutual respect, understanding that the sum is greater than the individual parts.

The new meaning of linkage with the surroundings is rooted in having the ability to interpret and anticipate change, take part in national and international knowledge and innovation networks, and know how to transfer, learn and share knowledge. The University-Industry linkage models that the Universidad de Talca has built give it a solid base from which it is possible to advance into more complex arenas.

5.5 Chapter references

Etzkowitz, H., and Leydesdorff, L. (1995), The Triple Helix: university–industry–government relations: a laboratory for knowledge-based economic development, EASST Review, Vol 14, pp 14–19.

Part 6

6 Final considerations and recommendations

Contributions from different areas as well as discussions regarding the analysis of the status of engineering curricula, in this case civil, forestry and agronomy engineering, and their relation to the role of the engineer are very important for the construction of an intervention into the situation.

The University must revitalize its relationship with society, using real life and its problems as the strongest vectors in the revision of knowledge; learning from facts facilitates the generation of an ethic of commitment for students, teachers and the institution. The generation of knowledge under the scope of ideal conditions leads to training engineers in an isolated manner, out of a social context, and that perpetuates the causes of problems.

Building awareness spaces will also allow professors to develop skills that will help them in teaching students to identify the existence of problems and to find solutions in a holistic approach. This may be improved by the creation of curricular subjects to solve complex environmental problems.

After having examined different universities' curricula and, considering need to integrate training on water and environment issues, topics that exceed the contents in themselves must be considered. As well, other aspects such as time availability for dictation, in the context of increasing pressures after a downward trend in the length of degree careers.

In regard to lectures and training, fundamental concepts should not be excluded, but actually, should allow compatible teaching with the new contents. This stresses the need for inclusion of environmental contents, in order to raise and answer global issues, as well as, local and regional ones.

The incorporation of additional contents in environmental issues requires adequate complementarity of universities' modular structures. It is worth noting, the current method of knowledge construction aims at specialization rather than integration. After consultations on topics of university accreditation and sharing the results of the project, it came about that difficulties of having flexible curricula could comply with the requirements of accreditation, which makes hard the inclusion of new contents. Taking intermediate results to the appreciation of directives and teachers, led to the proposal to incorporate environmental contents transversely, and also to integrate contents of related subjects.

The challenge stands on teachers' awareness on environmental issues; as well, on achieving the commitment of authorities and on strengthening the interest of students in those subjects. This way, the inclusion of the environmental variable could be obtained in a transversal mode.

In regard to Institutions of Higher Education, and as a way to promote these changes, it is necessary:

- To revitalize the University's relationship with society in order to consider practical needs for teaching and to integrate experiences from vocational training into curricula. This should explicitly consider a cooperation of universities with enterprises.
- To intensify the interaction of Universities with the regions to be able to take a vital role in the region-specific development.
- To promote internationalization of University's activities (cooperation and exchange at different levels) to broaden the horizon and share knowledge as well as experiences. This should be supported by unified international standards promoting exchange between educational institutions.
- To foster integration among different areas of specialization, integrating theory and practice, as well.
- To promote transdisciplinary views, projects, modules and courses at universities and especially in engineering faculties in order to establish a holistic view on environmental issues.
- To encourage activities of awareness for teachers, in complementary training courses, workshops, integration activities.
- To incorporate offers of integrated seminars, which are optional and complementary in the training of students.
- To promote the incorporation of researchers on water and environment issues at the teaching staff.
- To encourage complementary education of students and their participation in research and extension activities.
- To focus on the incorporation of environmental contents, through the activities mentioned above, defined as the consideration of regional environmental needs in a perspective of sustainable development, taking into account social, economic and environmental requirements.

These proposals are the result of CapWEM's cooperation activities between European and Latin American universities; they can be considered as general recommendations to improve higher education in water engineering and environmental management. They will help to modernize curricula and boost practical competencies of graduates. There are different recommendations how to adapt modern curricula to regional needs.

Concrete outputs could be achieved during CapWEM's implementation period. In several institutions of the partner universities ideas and proposals were applied in processes of curricula modernization. This happened for example in the process of civil engineering curricula revision in the partner university of Paraguay.

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