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INTERDISCIPLINARY EDUCATION AND RESEARCH IN MEXICO

by

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Abstract: In this article we discuss interdisciplinary teaching and research in Latin America through the lens of Mexican perspectives, in particular the experiences at the National Autonomous University of Mexico (UNAM). The history of these experiences goes back to the creation of the first interdisciplinary education programs in Mexico in the 1970s and the foundation of the Center for Interdisciplinary Research in the Sciences and Humanities in 1986 at the UNAM. With this Center's contributions as the framework, we examine objectives and instruments of academic policy in our country in order to understand how methods of evaluation work. We study not only the ways of academic interdisciplinarity but also the main theoretical and epistemological focuses in university environments. From this analysis of Mexican experience, we obtain important information that can be useful in the process of integrating knowledge amongst other countries of Latin America.

Keywords: interdisciplinary research, interdisciplinary education, academic policy, evaluation, interdisciplinary research training

Introduction

In recent decades scientific institutions and universities all over the world have promoted research projects and teaching programs that have interdisciplinary perspectives with high epistemic and practical value. Nevertheless, the study strategies that deal with multidimensional and more complex problems, such as the interrelation between natural and

social processes, are managed differently (Padberg, 2014). In addition to diverse approaches across institutions, knowledge is produced and evaluated by self-referenced communities that are strictly disciplinary (Weingart, 2010). As a result, interdisciplinary work is often judged by inappropriate criteria.

Half a century ago, the first international dialogue on interdisciplinarity among developed countries was held in Nice, France, co-sponsored by the Organization for Economic Cooperation and Development. The seminar examined ways in which knowledge was integrated into teaching and research in response to new challenges of society (Apostel et al., 1972). It also generated continuing reflection on existing institutional and political obstacles that are faced when people are trying to apply integrative perspectives (Darbellay, 2015). One of the main venues for scholarship on interdisciplinary studies, which extends investigations beyond the 1960s, has been the journal *Issues in Integrative Studies*, published by the Association for Integrative Studies (AIS, since renamed the Association for Interdisciplinary Studies as the journal itself has been renamed *Issues in Interdisciplinary Studies*). Since 1982 the journal has promoted work about interdisciplinary theory and methodology, as well as the relationship between social context, institutional structure, and interdisciplinary programs of research and teaching (See publications on the website of the Association for Interdisciplinary Studies, 2014).

North American and European visions of interdisciplinarity are widely spread internationally. *The Oxford Handbook of Interdisciplinarity*, for instance, represents the present state of research, education, and management of interdisciplinarity from the perspective of experts who are mainly from these regions of the world (Frodeman, Klein, & Mitcham, 2010). Latin American scholars of interdisciplinary work, however, feel it crucial to incorporate the vast experience that this region has in projects and universities into the literature. Doing so will expand understanding of how interdisciplinary projects begin, in which institutional organizations they start, and in what modes of academic work they have developed. With a greater understanding of a wider range of contexts, it will be possible to identify not only obstacles that interdisciplinary projects face, but also their pertinence and viability inside a particular historical and cultural context. Yves Lenoir (2013), a scholar who has written more widely than others on interdisciplinarity across countries, has identified a correspondence between logics of interdisciplinary research in countries with obvious cultural differences such as France, the United States, and Brazil. He highlighted in particular knowledge, action, and being, framed by the logic

(the reflexive function of knowing), instrumentality (the quest for answers to questions about society), and the affective domain (the realization of being human).

This article extends understanding by giving an account of interdisciplinary research in Latin America, in particular Mexico and specifically The National Autonomous University of Mexico (UNAM). It covers the emergence of the first interdisciplinary programs in secondary and higher education in the country, which in the case of the UNAM are strongly attached to the work of Pablo González Casanova and the creation of the Center for Interdisciplinary Research in the Sciences and Humanities in 1986. Using the Center's contributions to research and teaching as the primary reference, we examine objectives and instruments used in academic policy in our country to understand how methods of evaluation work. From this analysis, we will extract lessons about the Mexican experiences that will be useful in advancing the process of knowledge integration in other Latin-American countries.

Interdisciplinary Approaches to Education

The interdisciplinary approach in higher education in Mexico arose in the 1960s within the framework of a national university reform caused by the overcrowding of universities and their inability to satisfy the growing demand for higher education (Ramírez, 2002). It required the creation of new state universities, particularly in the metropolitan zone of Mexico City. It occurred during a period of relative democratic openness provoked by student movements in 1968 (Díaz Barriga & Garduño, 2014) and parallel social movements in various countries (López, 2004; Follari, 1982). In response, curricular innovations, which were encouraged by the largest higher education institutions in the country, aimed to promote critical thinking in students to understand and confront the social reality of the time (Díaz Barriga & Garduño, 2014). Most of the curricular designs were associated with the concepts of multi- and inter-disciplinarity because they had an objective of integrating knowledge based in modular study plans. The curricular design of "professional interdisciplinary units" from the National Polytechnic Institute (IPN) created in 1972 and from the UNAM National Schools for Professional Studies (ENEPs) created in 1974 have since their founding resisted multidisciplinary models (Reyes, 2001; Ramírez, 2002). In the case of the ENEPs, the approach to "instruction" and "service" in different majors focused on preparing students in their respective specialties though they had the added goal of complementing disciplinary formation

with professional practices of other disciplines. However, the main focus of attention was still on each student's own profession as an isolated practice (Cardoso, 1999).

As Burns (1995) explained, in multidisciplinary models students gain a broad amount of knowledge but do not perceive the connection of concepts and activities if they do not have integrative seminars or projects. They have to discover existing connections by themselves. Burns and Sattes (1995) distinguished three curricular designs based on degree of integrative knowledge. In the lower level of integration in the "design sequence" the contents and procedures of the disciplines remain intact, with only the order of presentation changing to help students explore topics of similar issues simultaneously. In contrast, interdisciplinary models generate a new "level of connection" and establish a new logic of learning and teaching based on nodes of integration in the form of subjects, problems, questions, and general concepts. The modular system of the Metropolitan Autonomous University—Xochimilco (UAM-X) and the Integral General Medicine program of the Faculty of Medicine at the UNAM (Plan A-36), both created in 1974, adopted the fundamental traits of the interdisciplinary model, anchored by a main core focused on social issues and the curricular modules surrounding the core.

The A-36 plan was created to train general care doctors oriented to social preventive and communitarian practice. It was a progressive plan in which students would begin with simple problems and then escalate to more complex situations (Cardoso, 1999). Instead of dividing basic and clinical subjects, as the traditional model does, this plan adopted a modular system with a constructivist approach (Díaz Barriga & Garduño, 2014). Each module functioned as an integrative area, linking knowledge from six areas: biology, psychology, sociology, epidemiology, pathology, and clinical medicine. The main objectives were to connect clinical practice with medical sciences and also to bring medicine closer to social needs (Cardoso, 1999). The plan lasted until the beginning of the '90s and most of its fundamental elements, such as the bio-psycho-social integration of early clinical practice, are still in place. The A-36 plan was an alternative model in the UNAM that wasn't explicitly interdisciplinary. Its emphasis on promoting preventive programs in specific marginalized communities was based on the explanation of health and sickness, influenced by both the environment and the socio-cultural surroundings of each community. This model wasn't aimed at training specialists (Viesca, 2011).

Even with some strong integrative features remaining in place, it is important to re-evaluate coherence between the study plan and the

professional profile expected from the program. In identifying some of the problems that occur, García Colorado and Morales (1993) report that coherence between the contents of the modules was not addressed epistemologically. Yet analysis of the plan's results showed that students graduating from this model integrated into very similar work fields to those of students graduated from traditional study plans (Marín, 1993).

The modular system of the UAM-X required curricular modules to work around a central concept of a “transformation object” that focused on social problems and integrated disciplines such as teaching research and service (Díaz Barriga & García, 2014). This model was also based on interdisciplinary design principles, which placed value on merging social issues, team work, active student participation in teaching and learning, and a combination of practice and theory in flexible spaces (Arbesú, 1996). The UAM-X postgraduate studies program also specified that the central subject had to be the interaction of knowledge, so that interdisciplinary formation was supported by the “development of abilities and capacities to combine, create and fuse together the processes and structures of unity and diversity” (Metropolitan Autonomous University, 1996).

The 1974 academic changes at the Ibero-American University (a private university) stand out because of their interdisciplinary emphasis. In this case the main subject was the development of abilities for problem solving. At the undergraduate level they aimed to build a comprehensive curriculum that was flexible and made it possible to choose subjects from different departments. By doing so, it allowed students to face problems with various solutions from different areas of study (Celis, 1996). According to the characteristics of integral designs that Lake has described (2004), we observe that this practice also promotes critical thinking and problem solving abilities. Lake adds that interdisciplinary pedagogy prioritizes application of knowledge, not simply acquisition. For that reason working with project-based learning is one of the main features of an interdisciplinary curriculum that is flexible and akin to the Ibero-American University experience.

With the exception of the A-36 plan, the other programs still operate under this integral design. Nevertheless, some innovations were limited and later devolved to reflect a more realistic view of the power of the curriculum to transform social and educational realities in an emancipatory sense. Díaz Barriga and Garduño (2014) attribute the failure of the utopic academic plans to internal conflicts of the leaders of projects and to administrative decisions. Cardoso (1999) considers that confusion between the concepts of multi- and inter- disciplinarity is one of the major obstacles to integrated curriculum design. However, the development of interdisciplines in new

areas such as molecular biology, informatics and neurosciences renewed interest in integrating interdisciplinary curriculums that emphasize connections, correlations, and groupings (Klein, 1996). Based on this growing interest, the aforementioned Mexican institutions have been creating interdisciplinary programs since the 1990s. The National Polytechnic Institute (IPN), the Interdisciplinary Center for Research and Environmental Studies and Development (CIEMAD, founded in 1996), and the Professional Interdisciplinary Unit of Engineering and Technology (UPIITA, founded in 1997) have integral designs oriented to the development of problem solving abilities (de la Rosa et. al., 2001; Servín et. al., 2001).

To cite a specific example, professional studies at the UNAM include an undergraduate program in genomic sciences (founded in 2003). The structure of the degree shapes acquisition of knowledge and development of abilities. The study plan has two components: a basic stage in which subjects are grouped by theme, and a professional stage in which students specialize in professional areas and apply their knowledge in genomic sciences (UNAM, 2004).

The general focus on interdisciplinarity at higher education levels differs from integral designs for bachelor degrees. Higher education disciplines have an academic-professional orientation formed by disciplinary ideals. The main learning activities in interdisciplinary education in bachelor degrees are based on creating questions and building answers. From a conceptual point of view, questions are organizing tools that help build rational thought. They also build connectors for integration (Newell, 2002). Development of abilities and knowledge integration are the most relevant activities in this level of study. Disciplines become tools for learning various subjects (Mathison Mason, 1989).

The UNAM initiated academic changes at the secondary and higher education levels in 1970 (Ramírez, 2002). During his rectorship from 1970 to 1972, Pablo González Casanova planned an academic reform project called the “New University.” This project helped launch the School of Sciences and Humanities (CCH). It also promoted a scientific- humanistic culture with interdisciplinary orientations at the high school level. Its curriculum was designed as an alternative to that of traditional schools and it included a critical education centered on the student with an emphasis on social sciences and humanities. Its main goals were to build two languages for students, math and Spanish, while also encouraging the study of natural and social sciences (Díaz Barriga & Garduño, 2014, p. 247).

Interdisciplinary Approaches to Research

In 1986 Pablo González Casanova promoted an interdisciplinary perspective in the context of research by creating the Center for Interdisciplinary Research in Humanities at the UNAM. This Center focused on four main research lines: 1. the issues of developing countries of Asia, Africa, and Latin America and the global situation; 2. the Republic of Mexico and national problems; 3. Mexico's federal states and society, economics, politics, and culture; and 4. issues of economic crisis and their alternatives. When it was transformed into the Center for Interdisciplinary Research in the Sciences and Humanities (CEIICH) in 1995, it incorporated subjects such as physics and math, biological sciences, and engineering. Since its creation, the CEIICH has focused on the study of social problems on a national and international scale, aiming to create an exchange of knowledge through a network of specialists in sciences and humanities. The academic community of the Center has a pluri-disciplinary formation, which means that it is organized in research programs with a varied range of interdisciplinary focuses (CEIICH, 1994; 2008). The pluri-disciplinary perspective covers a few categories proposed by Raymond Miller (1982) in his typology of interdisciplinary approaches to social sciences and their research experiences. At the CEIICH there are area studies, which include Latin American studies and urban-environmental studies. There are also life perspective studies, which include feminist research programs, racial and ethnic discrimination studies, and social rights. Finally, there are hybrid studies (Dogan & Pahre, 1993), which include historic sociology, political ecology, philosophy of law, and econo-physics.

A distinctive trait of the CEIICH is that it not only focuses on interdisciplinary research, but it also encourages studies about interdisciplinarity. It is through these studies that researchers learn theoretical, methodological, and epistemological aspects and also management processes and the institutionalization of an interdisciplinary approach to teaching and researching. The Center has also promoted the understanding of integration processes that prevail within the University and the comprehension of strategies that favor programs with this orientation.

The studies about interdisciplinarity conducted in the United States and Canada have been an important referent for the work of the CEIICH. The theoretical contributions are based in said studies. However, there is a differential contribution divided in three main aspects: a) the depiction of interdisciplinary research in the university environment of Mexico; b)

the identification of work styles and obstacles faced by work teams at the interdisciplinary research training programs at the CEIICH; and c) the interest in taking a closer look at the theoretical and methodological fundamentals of interdisciplinary research in order to study complex systems based on the perspective of Rolando Garcia. From this point of view there have been collaborations with researchers from Argentina, Chile, and Uruguay. These international networks focus on institutionalizing interdisciplinary ideas in Latin America and contributing with conclusions that will favor these geographical regions.

The catalyst for these studies within the CEIICH was provided by the First Conference for Interdisciplinary Experience that hosted 41 speakers from the IPN and the UNAM. Four key concepts emerged from the conference that explain the generation of an interdisciplinary approach:

- a) the need to broaden the vision to solve new problems;
- b) the need to enlarge the disciplinary vision to study more complex subjects;
- c) the identification of methodological resources in other disciplines; and
- d) the justification of research protocols in order to solve practical problems (Villa-Soto, 2000).

Regarding the fourth concept, in order to understand the justification of an interdisciplinary focus in the research programs at the UNAM, we conducted a study at the scientific research sub-system (SIC), which at the time was formed by eight centers and twenty institutes.

Previous studies revealed two basic modes of discipline integration: one applies concepts or theoretical knowledge (known as creating an “auxiliary interdiscipline”); the other modifies the boundaries of objects of study, generating hybrid areas (known as creating a “unified interdiscipline”) (Villa-Soto, Moncada, & Mendoza, 2005). In a sample of 30 percent of each research team at the SIC, 87 percent of respondents declared their projects had an interdisciplinary orientation (Villa-Soto, Moncada, & Mendoza, 2009). Results also showed a predominance of interdisciplinary specialization in a single field, a pattern that appeared particularly in areas of physics and biological sciences. This led us to pay closer attention to hybridization of fields of knowledge. After examining every project of the SIC, utilizing the UNESCO international nomenclature system, we confirmed that the UNAM knowledge integration process is characterized by the convergence of specialties from either a single or an adjacent discipline (Villa-Soto & Blazquez, 2010). This finding corresponds to Dogan and Pahre’s (1993) definition of “specialty hybridization,” which is described as a recombination

of science fragments. Regarding the understanding of nature and society in general, the acknowledgment of epistemic value prevails over the more practical problem-solving studies. However, a third of the researchers state that this perspective stems from the need to broaden disciplinary vision in order to study more complex systems. According to our study, this objective was actually met in the departments dedicated to geo-sciences and the study of environmental issues. Even though the areas of Mathematics, Earth, and Material sciences have closer proximity to a dynamic structural focus, they cannot be completely identified by it. On the other hand, the constructivist focus was never employed as a reference for complex systems (Villa-Soto, Moncada, & Mendoza, 2009). These two focuses of interdisciplinary research (a dynamic structure focus and a constructivist focus) have been followed at the CEIICH and the Center of Complex Sciences (C3). But the two centers have different ways of conceiving complex systems.

For the C3 the study of emerging properties in complex systems and the changes associated with their nonlinear dynamics is what is most relevant (Álvarez-Buylla & Frank, 2013). This idea of complex systems can be best examined from the point of view of dynamic structuralism, a research orientation in the direct predecessor of the C3, the Department of Complex Systems at the Institute of Physics that was founded in the 1980s (Villa-Soto, Moncada, & Mendoza, 2013). The C3 was created in a first stage in 2008 and was recently approved in this year to address issues from diverse branches of science by using common tools (mainly computer-based simulation methodologies).

At the CEIICH the study of conceptual problems as complex systems relies on the theory and methodology developed by Rolando García, who has a constructivist approach. His theory states that complex systems are defined by the conjunction of multiple processes, and that their interrelations build a structure that functions as an organized unity (García, 2006). Another important difference between interdisciplinary research at the two Centers involves their structure. The CEIICH organizes projects into research programs, formed by researchers that have a certain flexibility to work in crossed areas and projects. The C3 aims for collaboration among researchers through a flexible structure organized as a network. This web includes academics from 25 different institutions from all over the country (UNAM, 2016). This structure corresponds to a model of “wall-free centers” that has its precedent at the UNAM in the University Project of Non-linear and Mechanic Phenomena (FENOMECA), which is still in being (Villa-Soto, 2000).

The CEIICH is a part of the Subsystem of Humanities at the UNAM, and it emphasizes social subjects. The C3 is a part of the Subsystem of Scientific

Research, and it emphasizes the natural sciences. However, both centers have projects and researchers involved in both fields. Two main projects of interdisciplinary studies were hosted by the CEIICH: the work of Pablo González Casanova, who empowered the discoveries of the Life Sciences and the Sciences of Matter; and the work of Rolando García, who enriched the studies of Jean Piaget about genetic epistemology. Pablo González proposed inclusion of the sciences of complexity and emphasis on historical and concrete analysis in order to build new alternatives for critical thinking. Rolando García defined interdisciplinary research as a methodology to solve social problems that were conceptualized as complex systems. This body of work originated a program in the formation of interdisciplinary research. We will discuss its importance further below.

Scientific Policy and Evaluation

The 2000 Conference on Interdisciplinary Experience at the UNAM revealed two main sets of challenges and problems faced by interdisciplinary programs. One involves scientific policy in Mexico and the other the evaluation of interdisciplinary work. Although interdisciplinarity has gained greater importance in the country, there haven't been clear strategies in relation to public policies in science and technology that will actualize interdisciplinary work. For example, the federal government has special programs in science and technology that acknowledge the pressing needs of poverty, violence, health, and energy issues, amongst others. They also endorse responding to them in a multidimensional manner. In addition, during the 2001-2006 period of programming the federal government spoke about the formation of interdisciplinary groups in order to promote the development and strengthening of basic research (CONACYT, 2002). In the special program of Science, Technology, and Innovation (2008-2012) the same objective is stated in defining the Institutional Fund as a political instrument oriented to the development of high quality scientific research and the formation of high academic level professionals (CONACYT, 2008). In the 2014-2018 period there is also an isolated mention about the interest in promoting multidisciplinary projects as part of the Sectoral Program for Agriculture and Livestock (CONACYT, 2014). Moreover, there are explicit references to interdisciplinary groups and projects in special Science and Technology programs, but they lack real content and seem to be included only as a policy tool. When mentioned, the programs are referenced without procedures or mechanisms that may clarify the way to reach realistic interdisciplinary objectives. The case of Institutional Funds employed to

build interdisciplinary groups requires special attention since it relates to the guidelines used to evaluate interdisciplinary projects.

The Scientific and Technological Consulting Forum (FCCT) is an organization that advises the Mexican Presidency. In 2014 it issued a report by the National Council of Science and Technology (conducted from 2009 to 2012) about the evaluation processes that were employed in order to finance multi- and inter- disciplinary projects (Bocco et. al, 2014). The report describes the evaluation criteria, the characteristics of approved projects, and the problems faced by evaluation commissions. The report shows that there is a serious lack of preparation in evaluation committees, and that they fail to understand the meaning of these processes. Amongst all problems, they detected the difficulty that commissions have in understanding the difference between inter-, multi- and trans- disciplinary research. In order to stress the importance of the distinction of these research manners, the report cites a few pioneer articles as well as more recent work by Klein (2008) about the experiences of Europe and the United States. This literature underscores the necessity of differentiated evaluation, which also coincides with the discussions from the 2000 conference at the CEIICH where participants concluded that the nature of interdisciplinarity is associated with specific ways of organization and the development of academic work. However, differentiated evaluation is controversial. Some scholars believe that it should be regulated by the same criteria as discipline-based projects and that determining the plausibility of projects should remain crucial. Klein (2008) suggests that in order to evaluate projects that aim to integrate knowledge from various disciplines, it is important to find experts in multi-, inter- and trans-disciplinarity. Porter and Rossini (also cited in the FCCT report, 1985) propose incorporating relevant abilities when selecting the evaluation teams, so commissions become aware of the differences in types of integration. These suggestions are especially relevant when working with evaluation committees from CONACYT, because they are formed by specialists who have conducted multidisciplinary research. The problem is that these committees don't know how to distinguish between their type of research and trans- or inter-disciplinary approaches. This fact is exacerbated by the paucity of experts who actually understand the difference.

Analysis of approved and non-approved proposals at the CONACYT also offers insight about the quality of projects that are submitted. In the period from 2009 to 2012, there was a 61 percent approval out of the 310 evaluated projects. The rejected projects had multiple titles that included the terms "multi-," "inter-," and "trans-diciplinary." However, the percentage of approved projects decreases to 20 percent, when the total count of

registered projects is considered (Bocco et. al, 2014). In addition, 64 percent of approved projects have been individual. The FCCT report states that whoever is identified as an individual interdisciplinary researcher aiming to integrate knowledge from diverse disciplines is in reality better described as a pluridisciplinary researcher in the process of integrating and producing knowledge. In comparison, eight percent of approved projects belong to social sciences and humanities. This fact is confirmed by the UNAM, which is the institution with the most approved projects (20 percent in the 2009-2012 period). From the 37 approved and financed projects only one belongs to the humanities, while the rest (97 percent) are projects based on scientific research (Bocco et. al, 2014).

The titles of approved and highly financed projects usually allude to interdisciplinary specialties and auxiliary interdisciplines (Dogan & Pahre, 1993) within the fields of natural sciences. Some exceptions include projects that merge natural and social sciences, such as the group project entitled “Detection of Risky Lifestyle, Phenotype, and Genotype in Order to Prevent Chronic-Metabolic Diseases Such As Diabetes Mellitus and Arteriosclerosis in Young Adults from San Luis Potosí.” It is interesting that amongst the rejected projects there are more titles that refer to such fields, for example, “Environmental Crisis and New Population Dynamics: Migration Impact in Mexico and the United States of America,” “Proposal for the Development of an Ecological Organization Program through the Use of Geographic Information Systems in the Marginalized North of Tlaxcala,” and “Social Representations of Climate Change in Mexico. Bases for Preventive and Adaptive Educational and Communication Strategies.”

To conclude, the evaluating commissions face multiple problems, justifying a critical analysis of the process. The difficulty of developing studies in which the government intervenes involves not only their realization but also their evaluations. Committees would have to be familiar with the specific strategies of developing projects in order to conduct a proper examination of their merit. The report urged identifying characteristics that constitute a multi-, inter- or trans-disciplinary project. We highlight several of them. The first is that “the method must clarify the way in which the different disciplines are to interact, so that projects keep an integrated vision.” Moreover, proposals need to “clearly establish the way in which participants will interact” (Bocco et al., 2014, p. 38). Furthermore, it is also important to stress the “coherence between the different perspectives provided by disciplines and the theoretical points of view of participating individuals” (Bocco et al., 2014, p. 41).

Interdisciplinary Research Training

In order to face the previously cited issues, the CEIICH has prepared interdisciplinary researchers who have the ability of creating and evaluating projects within an interdisciplinary perspective. The Center also establishes clear methodological guidelines for studying complex social problems that are based not only in knowledge integration but also in skills needed for collaboration. One of the Center's contributions was the creation of the Interdisciplinary Research Professional Updating Course (DAPII). It was created in 2010 and includes the findings of the Interdisciplinary Research Seminar, in which Rolando García participated. It also integrated contributions of the first conference on interdisciplinary experiences at the University, which brought together directors of teaching and interdisciplinary research programs. The teaching course was further complemented by the Seminar on Interdisciplinary Studies and Complexity, which involved interdisciplinary scholars of theoretical and practical interdisciplinarity.

The work of these academics revealed two issues that require prompt attention: 1. the indiscriminate use of the term “interdisciplinary” in fields of teaching and research, which makes it very difficult for programs and projects to be properly evaluated; and 2. the expectation that interdisciplinary program students will integrate the knowledge they have acquired from different disciplines when there are no clear guidelines on how they might actually do so (Villa-Soto, 2000). In order to solve these problems, it is important to focus on the educational aspects of interdisciplinary work. The DAPII was created with the objectives of not only understanding and solving these problems but also of generating a methodology that helps solve social problems from an interdisciplinary perspective. Intended for teachers and researchers from both private and public institutions, the program has the goal of forming professionals capable of understanding what interdisciplinarity is and able to develop and evaluate interdisciplinary research (CEIICH, 2010).

The course is based on the idea that interdisciplinary research relies on multidisciplinary teams, formed by academics representing a mixture of disciplines, ages, and professional trajectories. Teamwork is crucial when solving complex problems not only because individual researchers contribute with knowledge from their own disciplines but also because some processes need to be re-examined and dissected into multiple levels that can be best approached when looked at from different fields of study. This methodology requires all subjects to acknowledge that they are a necessary part of the

object of study. The students are meant to consider what parts they play in the team and to understand their motivations to study issues not only under academic optics, but also under ideologies. From this critical point of view, the multidisciplinary team builds an epistemological common frame that defines questions and processes that it considers meaningful. This displays the researchers' concerns based on their personal values and opinions.

The theoretical fundamentals of collaborative learning have proven appropriate in this process of interdisciplinary formation (Villa-Soto, Romero, & Blazquez, 2015). And in this case they have been adapted to a mixed context that is both research- and academic-oriented. The DAPII is a postgraduate course that teaches students to work in teams to integrate knowledge and to build interdisciplinary research projects. Collaboration facilitates a mixture of knowledge and visions, rather than a single ideology. The course also applies didactic strategies that promote collective thinking instead of a single viewpoint. This builds a positive interdependence among students that prepares them to face cognitive conflicts with an openness to multiple points of view. Interdisciplinary projects require intense interaction, including vigorous discussions with flexible postures (Lyll & Meagher, 2007). Cognitive conflict is essential (Lee, 1997). Incompatibility between student preconceptions and new concepts shaped by collective work will occur. Yet conflict is necessary and must be faced openly if teams are to develop shared knowledge.

The course curriculum includes four modules. The first module is dedicated to knowledge from a historical perspective. It covers epistemological fundamentals of interdisciplinary research. The second module aims to review ideas of four authors regarding the process of integrating knowledge: a) Slavoj Žižek, a Slovenian philosopher who proposes a synthesis of Hegel's idealism, Marx's historical materialism, and Lacan's psychoanalysis; b) Edgar Morin, who studies the process of conjunction, which supports the course's collaborative focus; c) Pablo González Casanova, who emphasizes the importance of complex science and the construction of alternatives based on critical thinking; and d) Rolando García, who sees interdisciplinary research as a methodology to study social problems as complex systems.

The third module ensures students know different research experiences proposed by the CEIICH. The fourth and final module is designed as a workshop in which multidisciplinary groups of 5-6 students are formed. They elaborate a proposal for an interdisciplinary research project using the methodology of Rolando García, which is based on genetic epistemology. This theory transforms research problems into complex systems; in turn such descriptions of the functioning of problems provide a

basis from which to answer research questions. The methodology includes disciplinary differentiation phases and integration phases, in which fields are mixed together and form theoretical relations that determine the structure of the system. The relations emerge from a multiple phase process that covers general acknowledgment of problems, definition of research questions, formulation of hypotheses, and characterization of a complex system and its subsystems (García, 2006). Judging by the quality of proposals presented at evaluation conferences, which assess their interdisciplinary character based on the conceptualization of problems as complex systems, we can conclude that the achievements of the course are highly satisfactory.

The collective projects presented at these conferences, generally shown as graphic representations, review pre-established issues such as violence or public spaces in order to study their complexity, relating heterogeneous processes from different disciplines. Students also explain how “integration nodes” are created to articulate and support complex systems. They do all of this while focusing on social problems such as education, environment, health, and social development.

The success of the course is also evident in its influence on multiple academic programs. The DAPII has become an important influence in three different ways:

- 1) It spreads contents by teaching courses in several national universities dedicated especially to the fields of agriculture and livestock, such as the Autonomous University of Chapingo and the Postgraduate College;
- 2) It branches out to other teaching programs such as the Course on Interdisciplinary Research in Environmental Education for Sustainability (DIIIEAS), which is taught by the CEIICH, and the University and Education Research Institute (at the UNAM). There is also the Course for Professional Updating with a Perspective in Interdisciplinary Research (DPIID), which now collaborates with the National University of Costa Rica and the Postgraduate College of Puebla in Mexico;
- 3) It encourages academic exchanges with related institutions. In order to create a Latin American network of interdisciplinary studies, the course has promoted joint activities with the Interdisciplinary Space of the University of the Republic in Uruguay and the doctorates in Interdisciplinary Studies of Thought, Culture, and Society of the University of Valparaíso in Chile and the Autonomous University of Querétaro in Mexico.

These achievements and the high enrollments in the programs reflect the viability for programs of interdisciplinary formation in Mexico. From 2010 to 2014 the DAPII produced 170 graduates. In 2014 and 2015 the DIEAS produced 63 graduates (CEIICH, 2016). And in 2015 and 2016 there are 59 students enrolled in DIPIID.

Conclusions

The cumulative picture that emerges from this case study suggests that expansion of existing research programs is possible and that Mexico can contribute to creating a group of experts in management, direction, development, and evaluation of interdisciplinary programs with a focus on research or teaching. The country has made significant progress in encouraging an interdisciplinary focus at the level of higher education, especially in curricular design based on integration nodes in the context of social problems. Positive results support our belief in the importance of creating more coherent integral designs in the areas of teaching and learning (according to Lenoir, 2013).

One of the most important keys has been modifying course curriculum in order to create a nucleus that coordinates contents, knowledge, and learning strategies. This can be accomplished from a constructivist point of view, which is based in creating projects that inspire collaborative learning in order to study specific problems. These problems will determine the professional direction of students instead of submerging them into a rigid disciplinary system. In an integral design the teachers contribute with the disciplinary knowledge needed in the process of knowledge integration based on problem solving. The development of a scientific-humanistic culture in higher education, such as the one offered by the educational model of the School of Science and Humanities, has built a solid base for the study of interdisciplinary-oriented degrees. For that reason it is important to spread that model throughout the educational system of the entire country.

In order to build integral designs that remain coherent and successful it is necessary to expand the interdisciplinary research training program so that it can include the study of interdisciplinary focuses in education. The growth of these kinds of programs will help in responding to institutional obstacles faced by academic projects that feature an interdisciplinary perspective. In order to encourage projects focused on science and teaching, it is also important to create a group of experts. The process of creating them favors interdisciplinary research projects with methodological guidelines

that are appropriate for studying the relationships of varied disciplines. These guidelines must also be based on collaboration abilities so that social problems can be solved by people working together in complex systems. That will also facilitate increases in social science projects but will still require evaluation teams whose members are experts in the subject being dealt with as well as in the interdisciplinary process.

The institutionalization of interdisciplinary research underscores the importance of prioritizing knowledge integration in order to solve complex problems and to understand our reality, led by professionals trained in interdisciplinary research. This article shows that it is very important to boost knowledge strategies from an integral viewpoint based on the formation of experts in education and interdisciplinary research. It is crucial to encourage collaborative teamwork in basic education levels in order to prevent individualist postures that are centered in competition. This cooperation is the basic standard needed to promote knowledge integration abilities based in the mixture of various research disciplines in higher levels of education. It is necessary to create centers that focus not only on interdisciplinary research and on learning but also on the formation of interdisciplinary teachers and researchers who can eventually function as agents of change in interrelated processes such as a) curricular innovation in higher education that aims for the development of complex thinking; and b) institutional changes that motivate the creation of multidisciplinary teams by giving specific incentives to interdisciplinary research. The possibilities of collaborating among Latin American institutions in order to study common interests require that these processes spread out through more geographical regions.

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