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THE CONCEPTION AND ROLE OF INTERDISCIPLINARITY IN THE SPANISH EDUCATION SYSTEM

by

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Abstract: This article provides an overview of the role that interdisciplinarity plays in the Spanish education system. With this aim, we first describe the main conception of the term *interdisciplinarity* in texts written in Spanish, including other terms that have similar meaning. Then we review the role of interdisciplinarity in the Spanish curriculum at different levels of education, focusing fundamentally on compulsory education. This serves as the basis from which later to analyze Spanish research on interdisciplinarity. Finally, through results of this research and some examples of interdisciplinary school practices, we extract conclusions about the role of interdisciplinarity in teaching practices in the classroom.

Key words: Compulsory education, interdisciplinarity, Spanish education system, Spanish research on interdisciplinarity.

Introduction

The division of knowledge into disciplines comes from the human need to isolate the elements that surround us in order to understand and conceptualize them and to propose and solve problems through the benefit of our greater knowledge of the elements. These elements are not, however, isolated, and on most occasions solving the problems proposed requires contemplating relationships, that is, requires various disciplines to solve them (Navarro, 1994). This movement back and forth, from the disciplinary to the interdisciplinary, is certainly fruitful in research and also in teaching. However, teaching tends toward the disciplinary, which prevents taking advantage of the productive aspects of the interdisciplinary. Research studies in this area demonstrate this productivity, but interdisciplinarity fails to become institutionalized for one reason or another.

In this paper we focus on the case of the Spanish education system and aim to provide an overview of the role that interdisciplinarity plays in it. We first describe the conception of the term *interdisciplinarity* in texts written in Spanish, including other terms that have similar meaning.

1. On the Term "Interdisciplinarity"

The dictionary of the Royal Spanish Academy (2001) defines the term "interdisciplinarity" as "*the quality of being interdisciplinary*" and interdisciplinary as "*referring to a study or other activity performed with the cooperation of various disciplines*." In the *Dictionary of Scientific Research* (Tamayo, 2004), "interdisciplinarity" is defined as a set of disciplines connected among themselves and possessing definite relationships so that their activities are not produced in an isolated, separate, or fragmented way. These definitions are related to the perspective of interdisciplinarity as a methodological framework for research in which there is an integration of the theories, methods, and—in general—formulas of scientific action from different disciplines, a multi-dimensional conception of the phenomena, and the recognition of the relative character of scientific focuses when they are considered separately.

From a more general perspective, Cobo (1986) defines "interdisciplinarity" as "the set of existing and possible interactions between disciplines in the area of knowledge of their methods or the learning of these disciplines" (p. 29). Along similar lines, Gervilla (2006) indicates that interdisciplinarity "involves integration of disciplines, interrelation of disciplines: of the same area, of related areas, of different areas, and of directly opposed areas" (p. 77). Quintana (1997) explains that knowledge assumes unity, but in reality knowledge is constituted by a multiplicity

of knowledges. A tension can emerge between unity and multiplicity, and this tension can be resolved by interdisciplinarity. As an example of unity of knowledge, Quintana cites pedagogy, since pedagogy is based on philosophy, ethics, anthropology, psychology, biology, and sociology. Along these lines, the mathematics curriculum and, thus, mathematics education—seen as unity of knowledges whose goal is the teaching and learning of mathematics—are grounded in four disciplines: pedagogy, psychology, sociology, and the epistemology and history of mathematics (Rico, 1997). The same can be said of the group of areas of university knowledge that emerged in Spain with the Spanish Law of University Reform (LRU) of 1983, called "specific pedagogies," such as mathematics education, science education, language and literature education, experimental sciences education, musical expression education, bodily expression education and visual expression education. Some disciplines already have an interdisciplinary character, as in the case of the physical-natural sciences particularly due to the many different written, verbal, and visual forms of communication which are used in a multi-modal way in their teaching and learning.

From a curricular perspective, interdisciplinarity is a way of organizing the curriculum "around cores that overcome the limits of the disciplines, focusing on themes, problems, topics, institutions, historical periods, geographical spaces, human collectives, ideas, etc." (Torres, 1994, p. 29). From our perspective, this kind of pedagogical work gives meaning to education, emphasizing its ethical, political, and sociocultural dimensions. It is a matter of "achieving integration of fields of knowledge and experience that facilitate a more reflective and critical understanding of reality," while at the same time giving more importance to what is known as "learning to learn" (Torres, 1994, p. 31).

Some authors argue that a good way to teach is to imitate the real ways that scientists and professionals work from the varied fields of knowledge: "… how to imagine being a chemist, a sociologist, a geographer, a mathematician by consulting a textbook as the main source of documentation and research; how to conceive the creation of a designer, a novelist, a musician, a film director by copying stereotyped models to receive an evaluation score" (Torres, 1994, p. 13).

The goal of life is not to receive points; nor does professional and personal fulfillment lie in copying standard models. Further, the sources available for consultation are currently highly varied. Life, both personal and professional, requires creative responses to problem situations. It is also assumed that all

learning must be significant in order to be authentic. Why then does a linear-disciplinary model dominate rather than an interdisciplinary alternative that fosters significant learning? We can formulate the same question in another way: Why do so many difficulties arise when we propose interdisciplinary innovation in educational institutions? There are powerful arguments supporting interdisciplinarity. Arguments from psychology include Ausubel's vision of significant learning and Vygotsky's of the mediated construction and reconstruction of knowledge. Epistemology holds that science shares objects of study, and some sociological arguments involve a complexity in the search for solutions to problems that requires tackling them from multiple perspectives.

In reviewing the numerous activities organized by movements for pedagogical renewal and the varied practical experiences carried out in Spain, Torres (1994) argues and we would argue the following. Throughout the 20th century[1]—and, we would argue, in the first decade of the 21st—although there has been a tendency to use the terms interdisciplinarity, globalization, project methodology, etc., their projection in practice appears in specific experiences of renewal that continue to disappear and reappear in new ways. "However, we must recognize that the defense of interdisciplinarity is gaining unusual vigor in recent decades" (Torres, 1994, p. 47). Is it possible that the response to the education system's resistance to more democratic and interdisciplinary projects continues to function to control and separate intellectual labor and manual labor, as begun with the Industrial Revolution? And is this condition aggravated by today's knowledge society? Some authors argue that it is only a question of power and control of production, despite the fact that the consequences of competitiveness required by globalization[2] and the new technologies have improved workers' continuous education. Globalization constitutes a powerful argument for interdisciplinarity: "The world in which we have to live is already a global world in which everything is related, both nationally and internationally; a world in which the financial, cultural,

[1] The origin of terms like "center of interest," "globalization" (Decroly) or "project method" (Kilpatrick) occurs at the beginning of the 20th century, within the movement called the "New School" or "Active School." In 1897, Dewey writes: "The school should represent present life, a life as real and vital for the child as that lived in the home, in the neighborhoods, or in the field of play" (Torres, 1994, p. 31).

[2] We use the term globalization here to refer to the historical process of interrelation and interdependence of all societies on the planet in a single world ecosystem of economic, political, and cultural relations.

political, environmental, scientific, etc. dimensions are interdependent, and in which none of these issues can be properly understood apart from the others" (Torres, 1994, p. 31). For example, "in a class in the third year of elementary school, in discussing the films of the Marx Brothers, we link their production to the Depression era, which requires us to connect film to the historical context of another country" (Feito, 2006, p. 1156).

Although different authors develop different classifications, we could conclude that there are three basic ways of integrating the curriculum:

- Decrolian centers of interest, used in pre-school and the early years of elementary education. These are usually divided into three stages: observation, association and expression;
- Kilpatrick's project method, used in the early years of elementary and secondary education and, to a lesser extent, in higher education. This approach poses interesting questions for the students to answer in teams. Four steps are usually identified: deciding the purpose of the project, making a work plan, executing the plan, and evaluating the work performed;
- Integrated Didactic Units, used in both elementary and secondary education and to a lesser extent in higher education. We can consider the following stages: selection/justification of the core of experience; development of the map of the contents; specification of the didactic goals, methodology, adaptations, and evaluation.

Finally, as we have already suggested, we must note that there are terms related to interdisciplinarity that are not synonyms but have a close relation to it, as in the case of what is called "globalized" teaching. Gervilla (2006) indicates that such teaching will "procure the suppression of demarcations between the different areas" (p. 74) and concludes, after giving the characteristics of globalized teaching[3] for pre-school, that true globalized teaching includes interdisciplinarity. Navarro (1994) indicates that "the terms globalization and concentration or integration of contents are nothing but different names for the term interdisciplinarity as applied to the field of teaching methodology" (p. 214).

[3] Three of the characteristics are: This type of teaching will not include analytic distinction of learning; the activities are not broken up into sectors; and globalizing objectives of an immediate and practical character are pursued (Gervilla, 2006).

2. Interdisciplinarity in the Spanish Curriculum for Compulsory Education

In the area of basic compulsory education, a tendency to design ways of achieving an integration of knowledges is also included in the different laws governing the structure of education, with greater or lesser emphasis depending on politics at the moment.

We will now review the different education plans of the last 40 years in Spain: the General Law of Education (LGE) of 1970 (Ministerio de Educación y Ciencia, 1970), the General Mandate for the Organization of the Education System (LOGSE) of 1990 (Ministerio de Educación y Ciencia, 1990), and the current Organic Law on Education (LOE) of 2006 (Ministerio de Educación y Ciencia, 2006), with special focus on the last one of these. The current organization of the Spanish education system is presented in Figure 1. We must add that none of these laws explicitly mentions the term interdisciplinarity, although they may include other related terms, such as globalization, integration, etc.

2.1 The LGE

The General Law of Education (LGE) was enacted in 1970, during the last stages of the previous political regime (the Franco regime)[4] and assumes a much-needed reorganization of the education system in relation to the prior education law, known as the Moyano law, developed in the mid-19th century. In the LGE, compulsory education was called Basic General Education (EGB) and corresponded to a student learning period from 6 to 13 years old. Education for younger ages was called "pre-school" and was required. The teaching of older students—*Bachillerato,*[5] vocational training, and university study—also included in the law, were not mandatory either.

The term closest to interdisciplinarity that appears in this law is that of *globalized* teaching.

In the case of pre-school (oriented to children from 2 to 5 years of age), no guidelines were given concerning the form of education, although one could infer

[4] Franco's non-democratic regime ended in 1975, after 40 years, with the death of General Franco and the beginning of the current democratic period.

[5] The term Bachillerato refers to the last two years of secondary school, which are non-compulsory. It consists of college preparatory education usually pursued from ages 17-18 (see Figure 1).

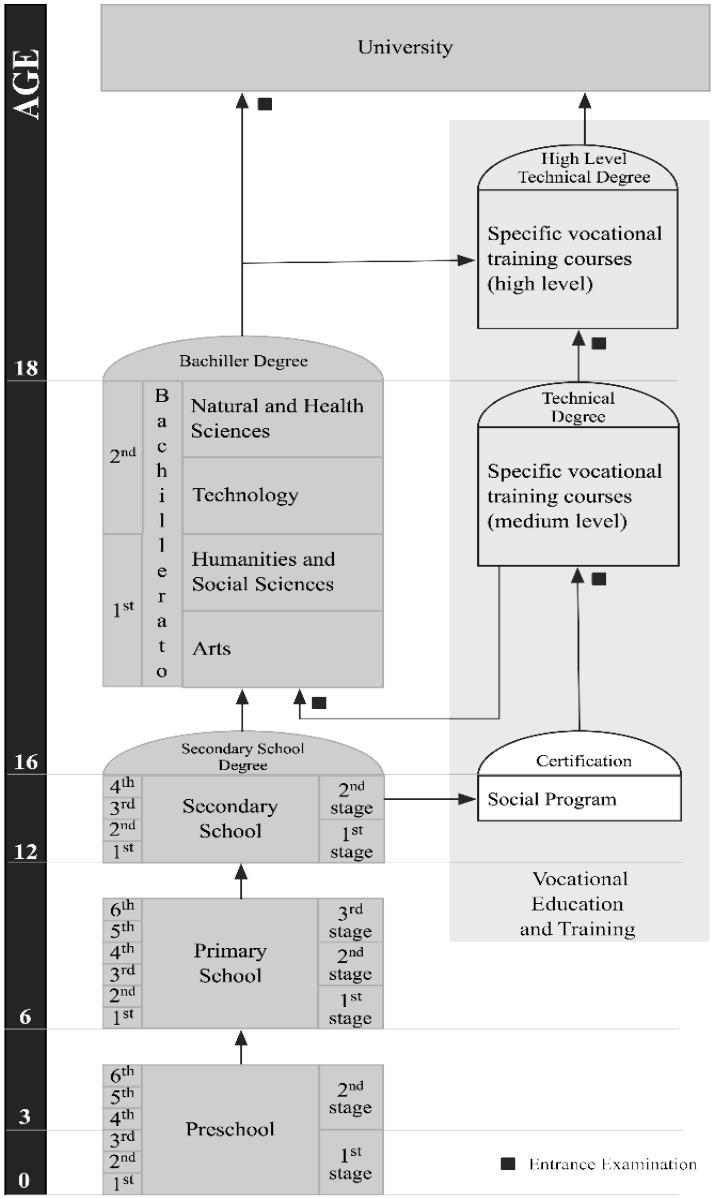

Figure 1. Current organization of Spanish education system.

that the law suggests globalized teaching following Decroly's ideas. Specifically, Article 13.2 (Ministerio de Educación y Ciencia, 1970) indicates that:

> Pre-school education, which is voluntary in character, includes education up to five years of age and is divided into two stages, which will be developed:
> a) In nursery school, which includes children from two to three years old, education, while systematically grounded, will have a character similar to that of life in the home.
> b) In the kindergarten for children from four to five years old, education will tend to promote the child's potential. (p. 21)

Article 14.3 states:

> The methods will be primarily active, to achieve the development of spontaneity, creativity and responsibility. (Ministerio de Educación y Ciencia, 1970)

In the case of Basic General Education, Article 15 of this law provides guidelines for teaching in each of the stages that compose EGB:

> 1. The goal of Basic General Education is to provide an integrated education that is fundamentally the same for all and adapted as much as possible to the aptitudes and capacities of each.
> 2. This level will include eight years of study, usually completed from six to thirteen years of age, and will be divided into two stages:
> a) The first level, for children from six to ten years old, will stress the globalized character of teaching.
> b) The second level, for children from eleven to thirteen years old, will provide moderate diversification of teaching by areas of knowledge, with attention to orientation activities in order to provide the pupil with subsequent options for study and work. (Ministerio de Educación y Ciencia, 1970, pp. 21-22)

The teachers of EGB had specializations in the physical-natural sciences, the humanities, language and literature, physical education, music education, or special education. If a science teacher in EGB taught the first phase, he or she taught as a generalist teacher, whereas teaching in the second phase meant that one was a specialized teacher. In other words, the children had only one

teacher in the first stage, and this teacher taught all of the disciplines except physical education, foreign language, and music education. The second stage added specialists in the sciences (mathematics, natural science, physics, and chemistry) and in the humanities (language, geography, and history). Even in the first stage with a single teacher for most of the subjects, instruction did not provide interdisciplinary treatment of the material, as each subject had its textbook and was studied separately and at different times.

In the rest of the non-compulsory teaching, there was no reference to a model of teaching that might be related to connection between the disciplines.

2.2 The LOGSE

The General Mandate for the Organization of the Education System (LOGSE) (Ministerio de Educación y Ciencia, 1990) was enacted in 1990 within the framework of the new period of democracy, adapting government regulation of education to the Constitution approved by the Spanish Court in 1978.

This law designates the educational periods as follows: Pre-School, Elementary Education, Secondary Education, *Bachillerato*, and Vocational Training. University studies are treated in an independent law: the Law of University Reform (LRU). For Pre-School (the period of teaching from zero to six years), the law indicated:

> Art. 9.4: The educational contents will be organized into areas that correspond to the specific areas of childhood experience and development and will be tackled through globalized activities that have interest and meaning for the child. (Ministerio de Educación y Ciencia, 1990, p. 28931)

For Elementary Education (period of compulsory education from 6 to 12 years of age), however, there is no reference to globalization like that in the terms used for Pre-School:

> Art. 14.2. The areas for this level of education will be the following:
>
> a) Knowledge of the natural, social and cultural environment.
> b) Art education.
> c) Physical education.
> d) Spanish language, the official language of the Autonomous Community, and literature.
> e) Foreign languages.
> f) Mathematics.

> Art. 14.3. The pedagogical methodology will be oriented to the general development of the student, integrating his or her different experiences and kinds of learning. The teaching will be personal in character and adapted to the different learning rhythms of each child. (Ministerio de Educación y Ciencia, 1990, p. 28931)

In this case, there is a prior distinction between the disciplines or areas: the methodology that enables integration of experiences and kinds of learning. One of the areas cited, the first one, does establish interdisciplinary treatment in considering three disciplines—nature, society, and culture—together. Further, the elementary school teacher is a generalist and teaches, although not together, the areas of Spanish language; mathematics; sciences of the natural, social and cultural environment; and art. There are also specialized teachers in three disciplines: physical education, music education, and foreign language.

In the case of Secondary Education, the only reference to interdisciplinarity through the term "integrative" appears in evaluation:

> Art. 22.1. The evaluation of compulsory secondary education will be continuous and integrative. (Ministerio de Educación y Ciencia, 1990, p. 28932)

Here, "integration" is oriented to the global consideration of the knowledge for the purposes of evaluation and not to a work methodology in the classroom that would involve a relationship between areas. The teachers in this case are specialists in one of the curricular areas.

2.3 The LOE

The current Organic Law of Education (LOE) was published in 2006 and replaces a law both prior and posterior to the LOGSE, the Organic Law for Quality of Education (LOCE), which was enacted in 2002 to be in effect for a minimum time period and was not developed for specific issues. The current LOE incorporates, however, some of the contents of the LOCE (Ministerio de Educación y Ciencia, 2006).

Although the guidelines related to an interdisciplinary approach are the same as those that appeared in the LOGSE and the LOCE, the LOE includes a new concept of curriculum that transcends individual levels of education, with special emphasis on secondary education.

> Art.6.1. As to the effects of what is proposed in this Law, we understand by curriculum the set of goals, basic competencies, contents, pedagogical methods, and evaluation criteria for each of the teaching areas regulated by the current Law. (Ministerio de Educación y Ciencia, 2006, p. 17166)

The incorporation of the "basic competencies" as a new component of the curriculum marks a curricular orientation related to interdisciplinarity that we will now analyze. This new component is not defined conceptually, but subsequent legislation does specify what the competencies are and the utility of the legal guidelines developed after the LOE, such as Real Decreto 1513/2006 on Elementary Education (Ministerio de Educación y Ciencia, 2006b) and Real Decreto 1631/2006 on Secondary Education (Ministerio de Educación y Ciencia, 2006c).

> Basic competencies, which are incorporated for the first time in the minimum requirements for instruction, enable the identification of those kinds of learning considered essential from an integrative perspective and oriented to the application of the knowledges applied. Their achievement should empower the students in their personal fulfillment, exercise of active citizenship, satisfactory incorporation into adult life, and development of continuous lifelong learning. (Ministerio de Educación y Ciencia, 2006b, p. 43053)

For the levels of compulsory elementary and secondary education, these basic competencies are:

1. Competence in linguistic communication.
2. Mathematics competence.
3. Competence in knowledge of and interaction with the physical world.
4. Information processing and digital competence.
5. Social competence and competence as a citizen.
6. Cultural and artistic competence.
7. Competence to learn to learn.
8. Autonomy and personal initiative. (Ministerio de Educación y Ciencia, 2006b, p. 43058)

The basic competencies constitute elements of interdisciplinarity, insofar as they are not exclusive to one of the disciplines but are related to all of them and, above all, mark a way of teaching and learning that has many moments of interdisciplinary and cross-sectional character. On the one hand, each subject matter contributes to each of the basic competencies, requiring teachers and students to reflect beyond the exclusive subject matter; on the other, it is necessary to establish complementary activities of an interdisciplinary character:

> Work in the areas and subject matters of the curriculum to contribute to the development of basic competencies should be complemented by different organizational and functional measures that are crucial for their development. Thus, the organization and functioning of the schools and classrooms, the participation of the students, the rules of internal government, the use of specific methodologies and pedagogical resources, and the conception, organization and functioning of the school library, among other elements, can encourage or hinder the development of competencies associated with communication, analysis of the physical environment, creativity, cohabitation and citizenship, and digital literacy. Likewise, ongoing tutorial activity can contribute in a crucial way to the acquisition of competencies related to the regulation of kinds of learning, emotional development and social abilities. Finally, the planning of complementary and extracurricular activities can reinforce the development of the set of basic competencies. (Spanish Ministry of Education and Science, 2006c, pp. 686-687)

In this sense, Rico and Lupiáñez (2008) indicate that this approach establishes new priorities for teachers, who should consider that their planning tasks should have an integrative character and not be linked only to one subject matter. For these authors, the model of competencies articulates instruction by means of: designing problem tasks, teaching students to mobilize resources to face tasks, and promoting meta-cognitive reflection in their problem-solving activities. These problem tasks should have certain characteristics:

- Complex: involve the use of a variety of resources;
- Goal-oriented: are oriented to actions with specific objectives;
- Interactive: involve interaction with the contexts of the tasks;
- Open: the results are not established;

- Unknown: new;
- Constructive: oriented to certain objectives. (Rico & Lupiáñez, 2008)

3. Interdisciplinarity as Object of Education Research in Spain

In Spain, interdisciplinarity has awakened great interest as a field of research in specific areas. We will now present a sample of the studies performed in the last decade, which enables us to draw certain conclusions that provide information about the role that interdisciplinarity plays in Spanish education.

3.1 Research on Interdisciplinarity in Spanish Education

We would point first to two studies performed in the area of physical education: Gil and Contreras (2004) and Conde (2004). The first consists of analyzing the popular motor games that appear in Cervantes' novel *Don Quixote* and designing an action plan for pre-school and elementary education. In this case, the areas involved were language and literature, science of the natural and social environment, and physical education. Their observations on this experience refer to the student's positive motivation and ease in attending to diversity. They also stress the motivation this required from the teachers.

The study by Conde (2004) analyzes physical education teachers' treatment of interdisciplinarity in elementary schools in the province of Cádiz (in the south of Spain). The study is qualitative and uses Group Discussion as the main instrument. Table 1 presents some of the results of the study.

Table 1
Objectives and Partial Results of a Study on the Treatment of Interdisciplinarity in Elementary Education (Conde, 2004)

Objectives	Results
Do the teachers in the study take interdisciplinary approaches?	- Half of the teachers surveyed judge that it is possible to carry out interdisciplinary proposals.
Factors relevant to interdisciplinarity	- Teachers have knowledge of the other areas of the curriculum. - Classroom planning is done jointly with teachers from other areas (at least some units). - Relevant learning and teaching improve to solve future problems. - Schools receive advising on interdisciplinarity.
Most relevant conditioners	- Teachers have insufficient initial training (theoretical and practical). - There are few courses in continuing education. - There is no joint programming; as such planning only occurs for complementary activities. - The textbook does not promote interdisciplinary learning. - The Delegation for Education does not encourage it. - The spaces, number of hours of instruction per week, and their distribution are not sufficient for the collaborative work that interdisciplinarity requires. - It takes too much effort. - Affective relations between the teachers are crucial. - Ideological commitment is fundamental.

Other experiences and research worth mentioning include:

a) "Philosophy in bilingual education (English-Galician) in Galicia" for *Bachillerato* (Torres, 2008). Bilingual teaching in itself constitutes a model of interdisciplinary teaching, in this case,

between philosophy and English: the student reads, listens, speaks and writes philosophy in English. One positive aspect of this experience is the need to simplify ideas to translate, while one negative aspect mentioned is the need to develop new material and difficulty in understanding.

b) "Mom, don't change the channel on commercials!" (Durán & Casanova, 2008). This is a didactic unit for elementary education that relates to the school subjects, art and music education, knowledge of the natural, social and cultural environment, education for citizenship, language, and physical education.

c) "Years of poverty, as told by our grandfathers and grandmothers" (Pérez, 2008). This study was carried out using the oral sources and interdisciplinary work in different areas of secondary education and *Bachillerato*: language and literature, geography and history, music, computer science, and theatre.

d) "Adopt a sculpture. Interdisciplinary project" (Bramon & Xandrich, 2008). The areas involved were Knowledge of the Natural, Social and Cultural Environment, Language, Mathematics, and Art.

e) "Learning French through historical memory" (Palma, 2008). This is a research study performed in secondary education that stresses the relationship with the environment and the limitations of the director of studies.

f) "Kandinsky in Pre-School and Elementary School" (Ledesma & Villanueva, 2008). This experience uses globalizing work in one pre-school and one elementary school classroom. It presents the excellent way of learning and working on culture involved in this method. The authors underscore that it is important to maintain the possibility of learning through dialogue and having a common object of knowledge.

g) "The educational trip" (Aparicio, 1998): This research study proposes the theory and practice of the educational trip, as an interdisciplinary project in secondary education involving the areas of social science, geography and history, and language and literature. The educational trip involves the exercise of cognitive abilities in natural contexts of high sociability. Some of the attitudes fostered are related to the contrast of opinions, the participation of the teachers and fellow students, teamwork, respect for different points of view, the elimination of prejudices and discrimination, and appreciation of life and beauty. As to skills, the authors stress spatial orientation, understanding of social reality, systematic observation, experimentation, analytic and synthetic systematization, reading comprehension and creativity. This is a very interesting interdisciplinary approach that groups the activities of each didactic unit into three moments: before, during, and after the educational trip.

The ways of integrating the curriculum in the prior research mentioned above and others to which we have referred can be seen in Table 2. We add bilingual education to the kinds indicated in Section 1, due to its specific characteristics.

Table 2
Methodologies Introduced in the Curriculum in Different Research Studies

Authors	Type of Methodology			
	Center of Interest	**Project Method**	**Integrated Didactic Units**	**Bilingual Instruction**
Feito (2006)		■		
Huber (2008)		■		
Gil & Contreras (2004)	■			
Conde (2004)			■	
Torres (2008)				■
Durán & Casanova (2008)			■	
Pérez (2008)		■		
Bramon & Xandrich (2008)		■		
Palma (2008)		■		
Ledesma & Villanueva (2008)	■			
Aparicio (1998)			■	
Cuadrado, Ruiz y Coca (2009)				■

The different interdisciplinary experiences cited use the following as teaching-learning strategies: assemblies, brainstorming, conceptual maps, tables, graphic representation, murals, use of news media, the classroom library, the textbook, telling one's own experience, daily diaries, educational visits, the use of Internet and the computer lab, periodic registries (temperature, menus, …), the school magazine, learning in pairs, workshops, oral presentations, use of audiovisual material, publication of books on the projects, creation of blogs and webpages, visits and interviews with invited experts, etc.

The common denominator of the different forms of integration in the curriculum is the use of a variety of curricular materials. Feito (2006) analyzes the materials employed in a center for pre-school and elementary education that performed an innovative educational project, observing that they used all kinds of books (some of these textbooks), encyclopedias, Internet information, pamphlets, some papers by the students themselves, etc. This study also stresses that the teachers had not determined the curriculum guide beforehand, that the students could decide the themes on which to work and that there was usually slight unease in some families, an issue to which the teachers had to devote attention. The students in this school also had a notebook—the school agenda—in which to record their homework, the weekly plan, and the contents for tests. Each student had a folder in which to keep the papers and worksheets completed or to be reviewed. The evaluation thus served to improve learning. The class also used something called the "important book," in which it recorded the most significant knowledge that the students acquired throughout the school year.

3.2 Results and Contributions in Spain

The studies presented in the previous section enable us to develop some relevant conclusions that help to describe Spain's situation relative to interdisciplinarity in education. There are teachers both committed and uncommitted to interdisciplinarity and the accompanying philosophy. Instability of the teaching faculty exacerbates this difficulty. Further, there are obstacles to the collaborative work among teachers, such as fear that others will take over one's own discoveries or unwillingness to stand out. The students' motivation with this kind of methodology is high, and, when done well, it improves their performance and their socialization process. In addition, because the involvement of families is usually important for the success of an integrated curriculum, the team of teachers needs to work on this issue.

Interdisciplinary work facilitates attention to diversity, enabling the adaptation of didactic materials and individualized attention. In recent years, there seems to be an increase in interdisciplinary proposals in all stages of the education system. However, disciplinary proposals continue to dominate. The literature review shows that there is great resistance to innovative interdisciplinary proposals, which come and go over time.

Some of the most important arguments that hinder interdisciplinary approaches are the lack of ideological commitment to these approaches, lack of sufficient knowledge, and insufficient support from the education administration and the school's leadership team.

Interdisciplinarity at the university is increasing in Spain as a result of the European convergence and the means for fostering innovation in teaching. Following the study by Huber (2008), we could group these into reflection as a general method of active learning, the project method (with the incorporation of research in teaching), cooperative learning, and the problem-based approach. Shuell (Huber, 2008) discusses the active participation of the university student, establishing fundamental principles: learning that is active, self-regulated, constructive, situated, and social. These traits are being found in the grounding of innovative methodologies receiving experimentation in Spain. In the future, it is possible that collaboration experiences between universities will increase, experiences like those presented in the work of Cuadrado, Ruiz, and Coca (2009) on implementing an interdisciplinary, bilingual, virtual educational project. Here, students at the London School of Economics and the Universidad de Valencia learned contents in economics and English. The results obtained by both universities support the positive influence of this interdisciplinary perspective on the students' performance.

With the aim of enriching the view of the role that interdisciplinarity plays in the teaching practice at Spanish schools provided by these studies, in the following part of this paper we describe two of the most frequent interdisciplinary experiences that are developed at Spanish schools. The first one is based on the use of photography and the second one on learning a second language in relation to the other disciplines.

4. Photography as Interdisciplinary Activity. A View from Mathematics

Photography is an activity that has great potential for the study and integration of different disciplines, from art, history, and communication to physics (mainly optics) and mathematics. At the same time, it is a remarkable

intrinsic motivation as it stimulates curiosity, gives rise to experimental work, which creates a sense of effectiveness, and promotes socialization (Stamovlasis, 2001).

Even though class work can focus on the entire process—from the choice of the object or situation to be photographed to the analysis of the product obtained (the photograph), which permits class work on very diverse physical concepts (e.g., the effect of light) and chemicals (e.g., developing techniques)—the most common teaching experiences focus on the last step of this process.

In Spain, many educational initiatives, usually promoted by teachers' associations, schools, or local cultural organizations, use photography to bring the students (and sometimes the rest of the population) into contact with contemporary history, culture, and art. In turn, they seek to promote observation, understanding, and critical spirit. For example, a recent initiative of the Council of Education and the City Hall of Santander sought, through 160 photographs taken from 1906 to 1966, to help students better understand the culture, customs, and traditions of this period and to deepen their knowledge of their ancestors in an appealing way.

Some interesting educational projects start from the use of photography to connect mathematics with the student's everyday environment or with other sciences. Among these, we stress the itineraries, gymkhanas, and mathematics competitions using photography that mathematics teachers' associations organize on specific occasions or annually to foster the appreciation and identification of mathematical objects in the immediate environment, as well as to connect mathematics to other disciplines through the search for and photographing of mathematical elements in specific spaces of cultural and/or historical interest. In searching for mathematics in our environment, we are making an effort to describe what surrounds us in mathematical terms, and this sometimes offers us a new vision of the important vestiges of culture and history that we find in our everyday activity.

We now illustrate some of these experiences through two examples.

4.1 Photographing Mathematics

The abstract nature of mathematics notions is one of math's essential characteristics and, at the same time, the cause of many of the difficulties that arise in learning math. Abstract mathematical notions are often used to solve problems in contexts that go beyond the merely mathematical. It is thus possible at times to "see" geometrical forms and properties, graphs, growth processes, and chance phenomena. Through the use of photography, it is possible to "capture" some of these mathematical notions.

One of the pioneering projects in Spain on the use of photography to carry out mathematics activities with students in compulsory education is the photography contest organized in the elementary school, Sierra Nevada in Granada (González, 1999). The original idea for the project was to give 12- to 14-year-old students from this school a problem situation that would combine mathematics, photography, and the environment in which they lived. The first of these contests was held in 1985.

The goal of the activity was for the students to:

- Discover environmental situations in which they recognized mathematics content.
- Take photographs of the place or situation chosen.
- Subsequently work from these photographs to:
    - Express a slogan, as creative as possible, to indicate the mathematical concept that motivated the photograph.
    - Discover new mathematics contents in the photographs.
    - Invent activities and problem situations from these activities.
    - Solve problem situations proposed by other classmates or teachers.

In developing the activity, each student had a field notebook and a disposable camera. For one morning and one afternoon, the students, accompanied by their teacher, followed a proposed itinerary and were completely free to take pictures of any place in which they "saw" mathematics. At the same time, they recorded a title for each picture that would describe the mathematics.

Years later, drawing on this experience on the occasion of the International Year of Mathematics, 2000, all of the schools in the province of Granada celebrated a Photography and Mathematics Contest. Field books were published with different itineraries in remote towns that included their most representative places (González & Rico, 2000). Since then, these activities have been carried out regularly in other Spanish schools, such as the public high schools of Zaragoza. The originality and in some cases sophistication of the results obtained by the students demonstrate the potential of this activity, as revealed in the photographs on Figures 2 to 5 (Alonso, Antolín, Bernardo, García & Pastor, 2001).

The students' ability to "capture" mathematics with a camera is surprising.

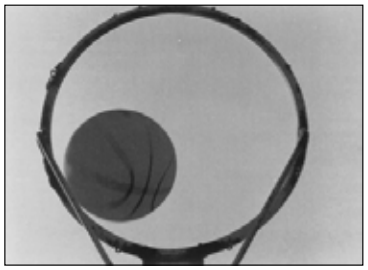

Figure 2. "Sphere Seeks Circle," by Isabel García (14 years old).

Figure 3. "The Sun Shares Angles," by Fernando García (14 years old).

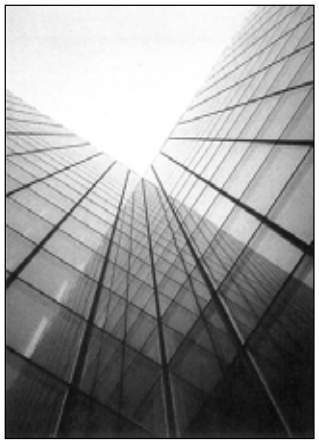

Figure 4. "Cartesian Axes," by Pablo Elipe (16 years old).

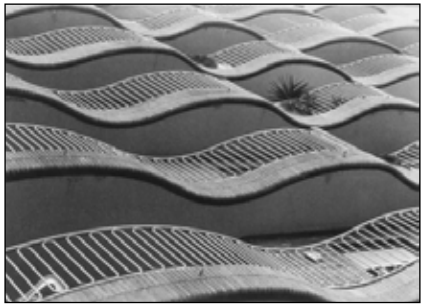

Figure 5. "Where Does the Sinusoid End?" by Belén Romeo (16 years old).

Photography is certainly a valuable resource for exploring how they see and interpret the mathematics that they come to know in the classroom. These activities develop, among other skills, their capacity to:

- Interpret the environment through mathematics;
- Apply, represent, and relate different mathematics notions;
- Foster the use of modes of expression related to mathematics;
- Observe, analyze, and classify the environment;
- Value mathematics positively as a tool for analysis and expression;
- Use critically the resources that technology offers them in contemporary society.

4.2 Photography and Mathematics in the Alhambra of Granada

The results can be even more interesting when the activity of photography and mathematics is carried out in a specific space with a great cultural and historical importance, one known for its wealth and variety of mathematics notions and problems. We find an illustrative example in a famous Nazari palace, located in the city of Granada and recognized in 1984 as an UNESCO world heritage site: the Alhambra (UNESCO, 2009).

Montesinos, Hernán, Fernández, Ruiz, Pérez, Lara, et al. (1995) describe the Alhambra from a mathematical perspective, presenting and solving problems that were proposed centuries ago by the artisans and artists of the Nazari Kingdom. The study of crystallographic groups, composition and decorations, the use of numbers, and the problems of tessellation are some of the approaches that these authors use.

Several years ago at the University of Granada, we organized activities on mathematics and photography at the Alhambra in the training programs for teachers in elementary and secondary education. The goal in this case was for the future teachers not only to locate mathematics notions visible in the different sections of the monument, but also to explain what problems these ideas solve or what utility they present. Some of the future teachers then coordinated groups of secondary students who, equipped with cameras, explored the monument from a mathematics perspective.

As a complement to these experiences, we would also mention publications of collections of photographs that reflect mathematics notions or properties (Molina, Libre, Quer, Cilleruelo, Romero, et al., 2000; Borrás, Moreno & Nomdedeu, 2002), include mathematics problems or questions posed through photographs (Gutiérrez, Gutiérrez & Queiruga, 2008; Recio, 2008), or relate mathematics topics to the sciences of photography (Friedman & Ross, 2003).

By focusing on the teaching of mathematics, we seek to show the multidisciplinary character of photography and its interest as a pedagogical resource on all educational levels, thanks to the wealth of situations and elements from outside the classroom that it enables students to bring into class, as well as issues involved in the process of developing a photograph and its important role as a means and support for communication.

5. Mathematics and Language: The Plan for Fostering Multilingualism in Andalusia

In 2005, the Plan to Foster Multilingualism was approved in Andalusia

(an autonomous community in the south of Spain) (Andalusia's Council of Education, 2005). The goal of the plan was to improve linguistic competencies in the mother tongue and give students multilingual and multicultural competencies. To achieve this goal, the Council for Education designed a new policy for different stages of education, grounded in the European theoretical principles agreed upon in the *Common European Reference Framework for Languages: Learning, Teaching, Assessment* (Council of Europe, 2001).

The Plan to Foster Multilingualism requires the creation of a network of bilingual schools in Andalusia that "will promote the teaching and learning of specific areas of knowledge in at least two languages, one primary language and an instrumental second language different from the mother tongue, for the teaching of specific areas or subject matters in the curriculum" (Andalusia's Council of Education, 2005, p. 7).

Other autonomous communities in Spain adopted curricular policies on language years ago, but Andalusia currently leads in the number of bilingual schools, with a total of 694 elementary and secondary schools in 2010, and the commitment of the government is that this experimental phase will be extended up to 1,200 schools in Andalusia before 2012. Regarding languages, 90% or a total of 625 schools delivered a Spanish-English bilingual program, followed by French in 57 schools (8%) and 12 in German (2%). And 68 more schools are expected to join the Spanish-English bilingual program in 2011 (Press Office of Andalusia's Council of Education, 2010). There was also a total of 24 programs that offer bilingual instruction in vocational training, delivered at 37 schools, mainly finance, management, and tourism schools.

Currently, the schools that belong to this network offer bilingual education only to part of their student body (one group per grade level), due to the fact that the implementation of the plan is in the experimental stage and also to the limitations of resources and linguistic training of teachers. The school chooses the students, normally based on criteria of academic performance and above all on prior knowledge of the second language.

At present, the program staff is formed of teachers in non-linguistic materials who also have accredited knowledge of some foreign language and who join the bilingual project voluntarily. Andalusia's Council of Education encourages the implementation of the Plan through different actions, such as a) fostering training of teachers in languages and in foreign exchanges, b) offering visits abroad for students and teachers, c) incorporating conversation aides in the schools included in the Plan, d) increasing the number of hours devoted to the study of languages in the school curriculum, and e) developing a plan to monitor all of the initiatives implemented.

However, the main changes in the language education policy in Andalusia are produced in curriculum design and methodology, inspired by the so-called CLIL model, which we will describe in the next section.

5.1 The CLIL Model of Teaching and Learning

The term CLIL, Content and Language Integrated Learning (AICLE in Spanish), was coined in the 1990s and refers to a pedagogical model in which "the materials or part of the materials are taught in a foreign language with the double goal of learning contents and simultaneously learning a foreign language" (Marsh, 1994).[6] That is, in the CLIL model, a foreign or second language (L2) becomes a vehicle for stimulating knowledge and developing abilities in other, non-linguistic materials that at the same time provide new contexts through which to develop L2.

The research on a second language acquisition has shown that greater contact with the foreign language contributes to increasing the level of competence in this language (Pavesi, Bertochi, Hofmannová, & Kaziannka, 2001, p. 110). The CLIL model specifically provides the opportunity for students to learn another language through greater quantity and quality of exposure to this language in other areas (without overburdening the school schedule and without it being an obstacle to learning of the contents of these other areas) and with greater motivation to learn the language, as a result of a methodology based on the resolution of tasks and of the "can do attitude" in the subjects taught in the second language (Navés & Muñoz, 2000).

CLIL incorporates many different modes of teaching and can be implemented in various ways and very different situations. Andalusia has established that 30%-50% of the non-linguistic areas involved be developed in the second language, and the teachers responsible for the bilingual section in each center decide to which particular units to apply bilingual teaching.

The implementation of a bilingual project in an elementary or secondary school is a complex task today. It assumes that the team of teachers of the departments involved works in coordination to develop an *integrated curriculum* for languages and the non-linguistic areas that coherently articulates the teaching of the different subject matters, seeking

[6] "CLIL refers to situations where subjects, or parts of subjects, are taught through a foreign language with dual-focused aims, namely the learning of content, and the simultaneous learning of a foreign language" (Marsh, 1994).

reinforcement between them and eliminating the repetition of contents. In contrast with traditional approaches, the integrated curriculum of CLIL involves a new focus on curricular integration and interdisciplinarity. It also means assuming a methodology based on cooperative, interactive learning and on the use of materials and technological resources, and reimagining the activity of the teachers who need to work in a multidisciplinary way.

5.2 Mathematics Within the CLIL Model in Andalusia

In November 2008, the Andalusia's Council of Education (2005, 2008) developed the "Integrated Curriculum of Languages" as a reference for the development of bilingual programs. This is a curricular and pedagogical project that includes only linguistic areas (L1, Spanish; and for L2, English, French, German). The document offers practical examples of the sequencing of contents and tasks for developing the contents, in both the first language (L1, Spanish) and the second languages (L2, English, French, German), in an integrated way with other basic curricular competencies, fundamentally in the areas of the natural and social sciences, in particular the area of mathematics.

The first difficulty that teachers encounter in teaching bilingual classes in general in Spain is the lack of reference materials and resources developed for this purpose. There is, for example, no bilingual textbook for the non-linguistic materials. Given this lack, schools have opted mainly to translate parts of Spanish textbooks or incorporate textbooks in the language of the project. In the former case, a mere change in the linguistic code in teaching does not incorporate the CLIL philosophy unless it also performs and integrates these codes into the curriculum on the other areas involved in the bilingual project. The second case presents the same problem in addition to the fact that the foreign curriculum does not have to be adapted to the Spanish one to be able to take advantage of a full text for an entire academic year.

This need to develop resources translates mainly into collecting and adapting to the needs of students specific didactic materials from countries where L2 is the mother tongue. Given that the Plan to Foster Multilingualism also seeks to promote knowledge of other cultures among the students, this search for foreign resources provides an extraordinary occasion to bring the students into contact with the situations and realities of the country in question, as well as to incorporate some of the methodological principles of other curricula. Specifically, the model of teaching mathematics in

the English-speaking countries provides the interesting opportunity to incorporate into Spanish the emphasis on the development of strategies of mental calculation and estimation of quantities, which in Spain are often replaced by teaching students non-intuitive procedures and algorithms for calculation.

In designing the integrated curriculum of a bilingual school, the mathematics contents can be integrated into the class on the mother tongue and foreign language in some of the following ways:

- Working on words that are difficult for the students to understand yet common in the mathematics class, such as exceeds, contiguous, classifies, simplifies …;
- Working ahead on vocabulary and grammatical structures in the foreign language that will be used in the mathematics class (for example, cardinal numbers, ordinal numbers, arithmetic operations, comparison, expression of the solution of an exercise, etc.);
- Describing objects using mathematics terminology;
- Emphasizing the definitions of geometrical figures and the use of logical connectors;
- Using as texts didactic readings on the topics of mathematics, biographies of famous mathematicians.

Conversely, from mathematics, we can design specific activities that enable us to integrate contents of a linguistic nature through cross-sectional contents such as food, consumption, ecology and the environment, geography, etc. As mentioned above, the CLIL model involves the design of interdisciplinary activities between different departments in a school, which implies reviewing the curricula in each area to find the points of convergence between the different areas and subject matters that can be developed from the different points of view that each contributes.

Bilingual education in mathematics is being introduced in most cases through specific contents and tasks in selected didactic units, so that the second language does not present an obstacle to learning the content of mathematics (in fact, the acquisition of content in the area, not the linguistic contents, is evaluated). Therefore, during elementary school and the first grades of secondary (especially if the students have not formed part of a bilingual program before), schools seek less to have the students produce their results in the foreign language than to expose students to other contexts different from those in which the language is usually presented to them in language classes, contexts like those that the subject of mathematics can

provide. They seek to facilitate familiarization with the second language in different ways: paraphrasing, presenting translations into Spanish of the more complicated parts of the text, reinforcing it with images, symbols, etc. In particular, the formal and symbolic language inherent in mathematics helps to reinforce the new linguistic contents presented.

As we have already mentioned, in practice teachers work together in order to design integrated learning tasks within a common topic. The solar system is one of the topics that can be covered from different areas —such as English, natural science, physics, geography, and mathematics—and therefore provides a good chance for teachers to plan interdisciplinary activities, like the set of integrated tasks that, under the title *Earth and the Solar System*, has been developed by the team of teachers in the bilingual section of the secondary school Sierra Nevada in Fiñana (I.E.S. Sierra Nevada, 2010).

The full document includes some worksheets with information on each heavenly body, to be worked on in English class. Thus, the project includes tasks from the perspective of sciences, related to climate; from physics, on the description of planetary motion and the change of seasons; from geography, on the names and characteristics of the planets as well of the cardinal points; and from mathematics, studying and comparing the size of the planets and the distances within the solar system. English is the vehicle uniting the different contents. The complete task is based on the interactive didactic Internet unit "The Solar System for Kids" within the Internet project *Starchild: A Learning Center for Young Astronomers* (The Starchild Team, 2008). This essentially mathematics task also enables us to introduce some cultural issues, in this case some English units of measurement such as the mile.

Conclusion

Different parts of this chapter provide information on the role of interdisciplinarity in Spanish education. We have shown that Spain is not committed to the interdisciplinary option in compulsory education, although the most current education law makes an important move in this direction. In the legislation regulating the curriculum, the term "interdisciplinary" is omitted, although there are other terms with similar meanings. It is in the most basic levels of instruction, which are not compulsory, that there is a commitment to interdisciplinarity. However, at the levels of compulsory and post-compulsory education, interdisciplinary projects are proliferating, on the level of autonomous communities and specific institutions or groups of teachers, and these projects are encountering significant success. Among these is the case of learning a second language in relation to the other disciplines, which is currently receiving special attention. Other initiatives are motivated by a particular occasion, as in the example of photography and mathematics described, but they are common in schools with motivated teachers excited about innovating in any of the disciplines.

Many issues still need to be developed to argue for a real presence of interdisciplinarity in the different levels of the Spanish education system. In spite of the new legislative reform on compulsory education that emphasizes the functional character of learning, there is no real planning that expresses how we can unify the knowledge, methods, and phenomena of different disciplines. University instruction only includes interdisciplinarity in the context of small collective innovations that cannot achieve the real goal of interdisciplinary training.

The same occurs in the field of research. Research focuses exclusively on designing and evaluating innovative projects based on interdisciplinarity. The body of studies is relatively small, and the reason may be that at these levels, although each discipline has a multidisciplinary character, it is constituted in a discipline that is closed, fearful that the others may take advantage of it.

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