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THE PROJECTION OF IMAGES IN THE SPANISH SECONDARY SCHOOL CLASSROOMS IN THE FIRST THIRD OF THE 20TH CENTURY

La proyección de imágenes en las aulas de bachillerato en España durante el primer tercio del siglo XX

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ABSTRACT: In the context of the research project ‘Dynamics of Educational and Scientific Renewal in Secondary School Classrooms (1900-1936): An Iberian perspective’. (HAR 2014-54073), an empirical study has been developed using the methodology of Content Analysis. This methodology has been applied to the set of educational visual messages that were projected all over the Historical Secondary Schools in Spain. The results of the studies reveal relevant aspects of the role that those elements of material culture had in the transformation of science teaching in the secondary school classrooms in the first third of the 20th century.

Key words: Science Communication, Education and Communication, Scientific and Educational Heritage, Projection Lantern, Diascopic Slide, Content Analysis.

RESUMEN: En el contexto del proyecto de investigación ‘Dinámicas de renovación educativa y científica en las aulas de bachillerato (1900-1936): una perspectiva ibérica’ (HAR 2014-54073) se ha desarrollado un estudio de análisis de contenido aplicado al conjunto de mensajes visuales de carácter divulgativo proyectados en los institutos históricos de bachillerato en España. Los resultados del estudio desvelan aspectos relevantes del papel que dichos elementos de la cultura material tuvieron en la transformación de la enseñanza científica en las aulas españolas de educación secundaria en el primer tercio del siglo XX.

Palabras clave: comunicación de la ciencia, comunicación y educación, patrimonio científico y educativo, linterna de proyección, placa diascópica, análisis de contenido.

1. THE PROJECTION OF IMAGES AND THE TEACHING OF SCIENCES

From the 18th century on, the projection of images reached an important cultural relevance thanks to a device that was referred to as “magical lantern”, “projection lantern”, “megascope” or “solar microscope”. This device became consolidated in the second half of the 19th century as a medium that entered all social spheres at a global scale. Projection sessions revolved around images recorded in slides that were generally made of transparent glass, and which were the base of any kind of public or private projection, either for educational or recreational purposes. These images illustrated everything, from fables and children’s tales to allegoric, comic, educational or current situations.

The projection slides were at the service of the general spreading of scientific and educational contents from the first half of the 19th century. The collections of educational slides reached all the spheres of knowledge and were exhibited in the public context of obligatory regulated teaching, in university departments, in scientific societies or in other public educational institutions. For this reason, it is hardly surprising that a very heterogeneous and competitive market emerged around the projection lantern that was subject to a diversified demand. This market ended up illuminating an incredibly fertile industrial and commercial activity that was oriented both to education and to entertainment, and which was targeted at two well-defined sectors: households, which included amateur audiences and children; and the professional fields, which required products and services addressed at institutions and public showings.

At the end of the 19th century, the projection lantern was one of the most commonly used resources in recreational science teaching, as can be seen in statements such as this one from the manufacturer Walter B. Woodbury, author of the educational brochure *Science at Home*:

The magic lantern has become, or is fast becoming, one of our best home teachers, and, besides amusing our little ones, it may be the means of spreading science amongst our friends, as its limits are by no means bound by the collection of photographic or coloured slides that we may possess. (Woodbury, 1874, p. 2)

Until the last quarter of the 19th century, sheets with illustrations made it possible to give a realistic look to those paradigmatic images that were created thanks to the collaboration between naturalists and artists, and that were meant to be used in the teaching of sciences in all sorts of educational contexts. In a way, they were the most successful forms of representation of the natural world, because they managed to make the natural objects that our senses could perceive come to life. For this reason, it is only normal that the projection slides from that time were mostly populated by images obtained from drawings or illustrations. This behaviour answers to what science historians Lorraine Daston and Peter Galison refer to as “truth to nature”, an epistemological value that emerged in the last decades of the 18th century and was in full force during a significant part of the 19th century. Understanding this so-called natural truth consists in distilling its regular features through the detailed study of the biological reality until an ideal version of each species, which did not exist in nature, could be materialized through its representation (Daston & Galison, 2007, p. 42). The knowledge of the naturalist, which is the result of many years of study and a close observation that is subject to a strict intellectual control, guides the talent and the hand of the artist to shape an image which will be assumed as true by others, including students in training.

However, at the beginning of the 20th century, a deep epistemological change starts to appear in the scientific field, not only with regard to the way in which it is practiced, but also in connection with

its teaching and learning. According to Daston and Galison, with the arrival of the 20th century, what they refer to as “mechanical objectivity” becomes the norm. This new trend does not aim to portray an idealized image of natural phenomena, but to merely capture each of those examples, with their peculiarities and imperfections. If at all possible, that image had to be achieved with the use of technical procedures that reduced the subjective look of the observer (Daston & Galison, 2007, p. 43). Among all these methods that could be used for this new epistemological pursuit, photography would soon reveal itself as the best ally of narration in the context of natural sciences (Daston & Galison, 2007, pp. 125-138).

The introduction of the projection lantern into the classrooms —which was also a result of that search of a “mechanical objectivity”— had a magical effect when it destroyed, symbolically, the walls of the academic laboratories to open a window to nature right in front of the students. Whereas the human anatomy is represented with projected sheets of perfectly healthy bodies and organs, animals are shown in a state of unique harmony with the landscapes where they live. The image seems to anticipate the encounter with the animals, thus preparing the students for one of the activities which best represents educational innovation in the first quarter of the 20th century: hiking trips and direct contact with the natural environment (Moreno González, 2007, p. 232).

Photographs in projection slides, for example, made it possible to teach one of the subjects most closely related to educational renewal in Spain: histology. Ever since Santiago Ramón y Cajal (1852-1934) received the Nobel Prize for Medicine in 1906, the study of animal and vegetal tissue became particularly relevant in the laboratories of the reference centre in Madrid: the Instituto-Escuela (Martínez Alfaro & Masip Hidalgo, 2012, p. 142). The projected photographs of the different types of tissues or the embryonic development of different animal species made it possible to educate students in the discipline that was in vogue and, at the same time, to educate them in the values of “mechanical objectivity”. Each of the images shown was an exact representation of a single laboratory experiment, and it reproduced a real result, without make-up or alterations. The artefacts that were inherent of histological research, such as dye stains or tears in the tissue caused by the microtome blade when it cut the sample, could be clearly seen in the image. Concealing them would have meant manipulating the “new truth”.

As in the case of sheets, clastic and detachable models, or naturalized animals before them, the collections of projection slides were also displaced with the arrival of new media, such as celluloid film, which brought with them new concerns and innovative educational and scientific challenges. Fortunately, not all the projection slides were lost. In the last decade, some research programs are recovering a large part of these educational materials which still need to be integrated in our heritage. After a process of restoration, study and explanation to the new generations, there is no doubt that they will again arouse curiosity in the classroom. These programs include two projects led by Leoncio López-Ocón Cabrera: 1) “‘Comprehensive’ education for young secondary school students: changes promoted by the JAE [Board for Advanced Studies and Scientific Research] in secondary education (1907-1936)”, which was the seed of the book *Aulas modernas. Nuevas perspectivas sobre las reformas de la enseñanza secundaria en la época de la JAE (1907-1939)* [Modern classrooms. New perspectives on the reforms of secondary education in the JAE period (1907-1939)], published in Madrid by Dykinson and the Charles III University in 2014 and which can be accessed online through the digital repository of the University; and 2) “CEI-MES. Science and Education in the Secondary Schools of Madrid (1837-1936)”, with a website (<http://ceimes.cchs.csic.es>) that gives access to a broad selection of the material culture stored in the Historical Secondary Schools of Madrid: Secondary School Cardenal

Cisneros, Secondary School San Isidro, Instituto-Escuela (currently Secondary School Isabel la Católica) and Secondary School Cervantes.

“Dynamics of educational and scientific renewal in the secondary school classroom (1900-1936): an Iberian approach” —a sequel of the two abovementioned projects— is another research project led by Leoncio López-Ocón Cabrera which studies the educational and scientific heritage that comes from the classrooms of the Spanish secondary schools, and which in this case focuses on the first third of the 20th century, a very fertile period with regard to scientific and educational production, according to Spanish and Portuguese historiographies. In Spain, this was due, among other reasons, to the dynamic nature of the JAE (Board for Advanced Studies and Scientific Research), the first instrument for the implementation of scientific and educational policies of contemporary Spain. In Portugal, this was due to the importance that education and science had in the First Portuguese Republic (1910-1926), which was considered a teaching State, and to the achievements of the *Junta de Educação Nacional* [National Education Board] that was created by the Estado Novo from 1929 to 1936. This dynamism in science and education was also influenced by centres who taught secondary education: the Spanish *institutos* and the Portuguese *liceos*. Their classrooms had a tendency to become laboratories which stimulated the intuitive abilities of students and promoted the principles of activity and experimentation.

Based on this historical evidence, the project “Dynamics of educational and scientific renewal in the secondary school classroom (1900-1936): an Iberian approach” aims to reach a triple objective before it is complete at the end of 2018:

1. To carry out an in-depth analysis of the profile of teachers who worked in the classrooms of Spanish and Portuguese secondary schools from a socio-professional approach.
2. To offer a global overview of the scientific materials that were included in the laboratories of secondary schools in order to establish their role in the spread of knowledge and the development of a more active and sense-based learning. We focus our attention on the collections of projection slides that are distributed in the different Historical Secondary Schools.
3. To establish the impact on contemporary society of the innovations that took place in the teaching practice of different secondary school subjects.

The triple objective of “Dynamics of educational and scientific renewal in the secondary school classroom (1900-1936): an Iberian approach” was used to delimit the empirical study of content analysis that is summarized in these pages under three criteria: a) the scientific and educational dimension of the heritage contained in projection slides; b) the time frame of the first third of the 20th century; and c) the geographic area of the Iberian Peninsula and, more specifically, of Spain.

The best testimony of the systematic use of image projection in secondary school classrooms in Spain during the first third of the 20th century is the presence of many collections of diascopic slides which are currently kept in the secondary schools that have survived from the network of Historical Secondary Schools. Diastopic slides are glass devices used for projection lanterns which show exclusively one isolated image per slide and with similar physical dimensions: about 8.5 cm x 10 cm. Those slides were generally part of collections that could be projected sequentially on a screen through mechanical procedures —with a simple projection system— or with a light system —composite projection system—. Therefore, with a simple change without a visual transition or a fade-out that connect them, two or more different images from the same sequence can be alternated.

The use of diascopic slides for scientific teaching in the Spanish secondary school classrooms during the first third of the 20th century runs in parallel to the use of projections in Europe for the

recreational dissemination of scientific knowledge, as can be seen in the editorial published in *The Wellingtonian* in March 1889:

It is illusory to imagine that the average student in our country has the slightest interest for science of any kind. They would undoubtedly be willing to swallow those pills of knowledge if they are sweetened enough, and therefore, they will not reject a lesson in Natural Sciences if it is accompanied by a good dose of lantern slides; the more views are projected, the greater their enthusiasm, so that, if they were given the choice, they would rather have an illustrated talk in which the talk itself was not present at all. (Crangle *et al.*, 2001, p. 99)

In fact, the influence of projections in the renewal of scientific education in Spanish secondary school classrooms was already widely discussed during the first third of the 20th century. For example, Antonio Marín Sáenz de Viguera, professor of Natural Sciences in the Instituto-Escuela of Madrid since 1920, wrote about the objectives of the “Teaching of Biology for students aged eleven to seventeen years” (Marín, 1925, p. 221) and confirmed this: “They are a first-rate auxiliary device. They make it possible for the first time to project, for the entire class, sheets from books, photographs of different creatures, scenes of the life of animals in their own environment and perspectives of places or countries that we cannot otherwise access” (Marín, 1925, p. 267). The arguments of Marín were shared by Federico Gómez Lluca, who was also a professor of Natural History and Physiology and Hygiene in the Instituto-Escuela, and who wrote the objectives of the “Teaching of Geology, Physical Geography and Cosmography for students aged eleven to seventeen years” (Gómez, 1925, p. 271). Gómez Lluca agrees with Marín on the relevance of images to illustrate natural phenomena in an educational environment:

In the classroom, we need and we use diagrams, drawings, photographs, maps and everything that may be used to make the daily explanations clearer. Most of these elements are projected or drawn on the blackboard, and the slide collections give the students more possibilities to understand these phenomena. (Gómez, 1925, p. 272)

Image 1. Nine diascopic slides about Geology from the German manufacturer Benzinger—distributed in Spain from 1924 by Eimler, Basanta & Hasse—which were used to illustrate this subject in the Instituto-Escuela of Madrid.



Source: Compiled by author from the Collective Catalogue of Spain's Bibliographic Heritage

2. CONTENT ANALYSIS APPLIED TO DIASCOPIC SLIDES

Content analysis is a scientific technique which makes it possible to carry out detailed and in-depth research of any material which is the result of human interaction. Therefore, it can be an essential tool for the organized description of the messages from any social medium. As an instrument for the collection of information, it facilitates the task with large heritage repositories by establishing the cumulative presence of unchangeable elements that can be seen in the educational visual messages that were used with the lantern in the classroom. In addition, it makes it possible to carry out a statistical assessment of the internal relationship between those invariable elements in order to formulate indicators that define their stability and provide answers to the research questions of each study. As Igartua claims (2006), content analysis is a research technique with which we can discover the DNA of communicative messages.

The empirical study of content analysis which is summarized below generally intended to research the role that diascopic slides played in the renovation of scientific education in the Spanish secondary schools during the first third of the 20th century, and it was developed in the context of the research project “Dynamics of educational and scientific renewal in the secondary school classroom (1900-1936): an Iberian approach”. This study involved different tasks that started with the identification of every diascopic slide that could be found in the Historical Secondary Schools. Many of these slides were classified in the Collective Catalogue of Spain’s Bibliographic Heritage (hereafter, CCBH), which is managed by the Spanish Ministry of Education, Culture and Sport.

The collection of diascopic slides was established as a unit for analysis, and then we formulated the following research questions that would guide the empirical study and that had to be coherent with the general objective of the research project:

1. What types of scientific contents are represented in the collections of diascopic slides that can be found in the Historical Secondary Schools?
2. What type of educational approach was used to represent academic contents in the collections of slides?
3. What is the country of origin of the collections of slides?
4. What type of technique was used to produce the images of the slides?
5. What is the degree of codification of the collections of slides?
6. What is the level of complexity of the scenes in the collections of slides?
7. What types of cultural traditions were used as a reference to represent academic contents in the collections of slides?

After defining the research questions, we conceptualized the messages included in the repertoire of diascopic slides until empirical variables could be deduced, in order to make them operational, that is, in order to obtain systems of categories with which we could quantify them and encode them according to the principles of mutual exclusion, homogeneity, exhaustiveness, pertinence, clarity and productivity.

After this stage, we designed the codebook, a document intended to register systematic information from the collections of educational diascopic slides. José Luis Piñuel (2002) describes the codebook as a sort of questionnaire that the analyst completes as if he or she were a survey taker asking questions to him or herself and answering according to the way in which each analysis unit—in this case, the series of diascopic slides—is read, heard or visualized. A good protocol for content analysis is based on an optimum design of the codebook, a document that provides an operating definition of each of the variables analysed in the series of diascopic slides and that acts as an “instructions manual” designed specifically for any research work that uses this methodology. For this reason, one of the goals of this text is to describe the “instructions manual” and to list the most relevant results obtained from the research questions that had been formulated.

Information about the collections is obtained from two types of observation: direct observation of the diascopic slide as an element of material culture, and indirect observation from other elements that make it possible to interpret the meaning and sense of the slides in their educational context. This second category, indirect observation, must in many cases be inferred from the complementary documentation that comes with the slide: texts prepared for readings that accompany the projection, statements from contemporary observers or hypotheses from researchers on this topic.

In order to achieve the goals of this study, the codebook takes into account the set of research questions that have been used to develop the operating definitions of the relevant variables for the empirical study, and which will be used to encode the representative sample that has been selected. In

order to make a clearer presentation, the codebook presented here lists the relevant variables that are analysed based on the conditions of production, distribution, exhibition and reception of the educational diascopic slides. These factors provide information about the patterns and routines of the manufacturers, the distributors, the teachers and the students in the context of the classroom, and they are organized based on the following sequence of variables: types of scientific contexts and educational approaches; countries of origin; formats, techniques of graphic register and formulas for graphic encoding; and, finally, degree of complexity of the scenes and cultural traditions of reference.

The codebook includes the following information for each of the relevant variables mentioned above: name of the variable, operating definition and abbreviated name, and operating definition of each category or category system, and its full text can be seen in “Los recursos didácticos de carácter visual y la renovación de la educación científica de los bachilleres españoles (1900-1936): un estudio empírico de análisis de contenido aplicado al estudio de las placas diascópicas” [Visual educational resources and the renewal of scientific education in Spanish secondary schools (1900-1936): an empirical study of content analysis applied to the study of diascopic slides], published in the proceedings of the 13th Conference of the Spanish Society for the History of Science and Technology (University of Alcalá, 21-23 June, 2017).

In order to ensure the consistency of the codes included in the book, the protocol of content analysis was developed and it was subject to a test to verify the validity of its contents with a board of experts which included Leoncio López-Ocón (Institute of History. Spanish National Research Council), Encarnación Martínez (Professor of Geography and History. Secondary School Isabel la Católica, Madrid), Carmen Masip (Professor of Geology. Secondary School Isabel la Católica, Madrid), Francisco Javier Frutos (Faculty of Social Sciences. University of Salamanca) and Beatriz González de Garay (Faculty of Social Sciences. University of Salamanca). The experts showed a high degree of consensus, and the content analysis could therefore continue.

Once that the codebook passed the validity test —and that we ensured that the book “measures the variables that need to be measured and that all the necessary elements or features have been included” (Igartua, 2006, p. 211)—, a representative sample of catalogued diascopic slides was selected under the direction of the CCBH, and more specifically, thanks to the excellent work of Manuela Carmona García, the head of the Department of Special Materials. At the time the study was carried out the set of slides was made up of the contributions from the following Spanish Historical Secondary Schools: 1,250 slides from the Secondary School Cardenal Cisneros (Madrid), 198 units from the Secondary School Isabel la Católica (Madrid), 996 slides from the Secondary School San Isidro (Madrid) and 495 items from the Secondary School El Greco (Toledo). Other historical centres like the Secondary School Bárbara de Braganza (Badajoz), Secondary School Brianda de Mendoza (Guadalajara), Secondary School Cervantes (Madrid), Secondary School Vicente Espinel (Málaga), Secondary School Zurbarán (Badajoz) and Secondary School Ramiro de Maeztu (Madrid) have more diascopic slides catalogued in the CCBH, but they have not been digitalized.

The slides selected as the sample for the empirical study are a representative part of the collections stored in the abovementioned centres. This is the case, for example, of the slides from the Secondary School San Isidro of Madrid, which has historically been one of the most important and renowned Spanish education centres since it was founded in the 16th century. In spite of the endless changes in its name, this school has survived to our days and it has become integrated in the field of secondary education, with one of the largest and most important collections of scientific and educational instruments. A large part of that collection was acquired in 1771 for the Chair of Experimental Physics, which required instruments for the demonstration of the study of electricity, mechanics, heat,

optics, acoustics, etc. All along the 19th century, the laboratories of physics and chemistry and natural history of this school received more items, as expected in a centre that wanted to be on a par with the best education institutions in Europe. The collection of slides which is currently in the National Museum of Science and Technology of Madrid comes from the Secondary School San Isidro of Madrid, and it is made up of 1,167 pieces, approximately 80% of which come from the school. It is a collection of educational slides that is a good sample of the thousands of sets of slides that illustrated geographic or scientific topics, as well as some sophisticated mechanical pieces that could be inserted in the magic lantern to show experiments of physics, chemistry, electricity, magnetism, microscopic observation, photopolarization, etc. A large part of the slides that make up the collection of the school come from the London firm Newton&Co., which was specialized in the educational applications of the magic lantern. Its commercial catalogue from 1909 included at least 187 pieces from devices that could show on screen different demonstrations of physical phenomena with the use of a scientific lantern, together with over 100 pages for collections of images of histology, botany, bacteriology, geography and history.

It has been estimated that the slide collections selected as a representative sample for this study have similar characteristics to other collections that may have been present in other secondary schools of Spain during the first third of the 20th century, and which, unfortunately, have not survived until our days. Those collections were part of the academic libraries of the Secondary Schools, and like the rest of the materials in there, their main objective was to be an educational support for the subjects that were taught in the centres. The collections in these libraries and laboratories contained monographs and reference books from all areas of knowledge; maps used in the study of geography and to understand the different historical periods, geological regions, or large panels that, thanks to their clarity and their faithfulness in representing the originals, were essential in the study of zoology, botany or human anatomy. Academic libraries progressively incorporated new materials and equipment such as projection lanterns, microscopes or three-dimensional models of plants and animals, which were ultimately stored in science laboratories. The monographs and works of reference always had a special place in the libraries, in comparison with all these “special collections” which were regrettably subject to poor conservation conditions because they were undervalued or replaced with more innovative materials.

In order to understand the market around the materials associated to the projection of images that teachers in secondary schools could access, it is necessary to know the editions of sales and rent catalogues of equipment and slides, which in some cases were over 1,200 pages long—in two volumes—and which included between 100,00 and 200,000 slides. A good example of this type of publications is *Cultura. Material pedagógico para institutos, escuelas normales, escuelas nacionales, y demás centros docentes* [Culture. Educational material for secondary schools, normal schools, national schools and other education centres], edited by the German manufacturer Eimler, Basanta & Haase, and published in Madrid in February 1932. Section XVI—Culture—of this catalogue contained an offer for “projection equipment” (Eimler *et al.*, 1932, p. 40), which included all sorts of devices and glass slides created by the German company Benzinger, on many different topics—“Religion, Geography, Universal History, Art, Physiology, Zoology, Botany, Geology, Paleontology, Agriculture, etc.”—(Eimler *et al.*, 1932, p. 42). The text reminds us that the slides were selected “carefully by professors and educators, and they were studied according to their scientific and technical perspective” (Eimler, *et al.*, 1932, p. 42).

The next stage was training the coders—Francisco Javier Jiménez Amores, Rebeca Gracia Lara and Laura Rodríguez Contreras—. The contents of the sample were encoded according to the instruc-

tions of the codebook and tests were conducted to verify intercoder reliability. Lombard, Snyder-Duch and Campanella state that intercoder reliability “is the widely used term for the extent to which independent coders evaluate a characteristic of a message or artefact and reach the same conclusion” (2002, p. 589). Although there are many scores for intercoder reliability, we cannot claim that there is an established consensus around one of them which is completely infallible. For this reason, we decided to use two different indexes in our calculations: Krippendorff’s Alpha —used for any number of coders, it satisfies the most relevant criteria for a good measurement of reliability—, and the simple percentage of agreement. Unfortunately, not all the variables in the codebook reached the minimum values for Krippendorff’s Alpha that are desirable in exploratory research —over 0.70. The variables related to the “graphic register”, “level of graphic encoding” and “complexity of the scenes”, which are closely connected to research questions 5, 6 and 7 were below that threshold. Fortunately, this was not the case of the simple percentage of agreement on the main code that was used to reinforce the reliability of the dual nominal variables. In this case, they all reached the minimum value that is desirable for exploratory research: over 0.80.

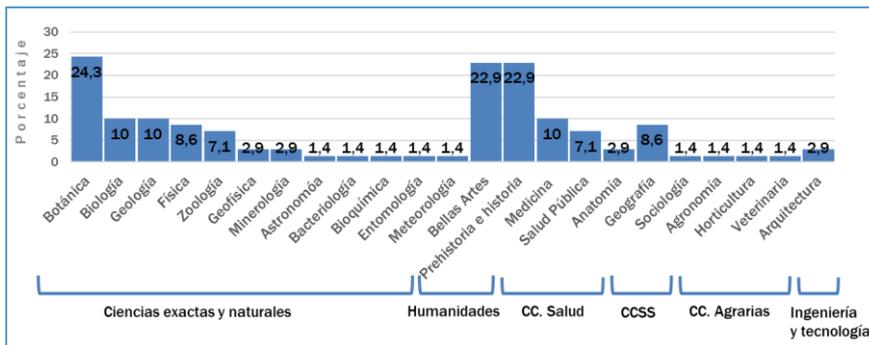
3. RESULTS AND GENERAL DISCUSSION

The main results in this study try to give an answer to the seven research questions listed above, which were used as a guide to establish the general objective of this work: understanding better the role that diascopic slides played in the transformation of scientific teaching in the Spanish secondary education classrooms in the first third of the 20th century. However, the decision was adopted to remove the quantifiable information related to questions 4 and 5, since the variables associated to those questions (“graphic register” and “level of graphic encoding”) did not reach the minimum values in the indexes of intercoder reliability that ensure consistency of results. Similarly, the results related to question 6 have been removed, because the analysts could not have access to enough complementary data to safely choose between the three different categories of the variable “complexity of the scenes”.

In order to answer the first question (“What types of scientific contents are represented in the collections of diascopic slides that can be found in the Historical Secondary Schools?”), we need to take into account the fact that six large groups and subgroups were established according to the six main knowledge areas established by UNESCO: Exact and Natural Sciences, Humanities, Health Sciences, Social Sciences, Agricultural Sciences, Engineering and Technology.

Figure 1 shows a distribution of the different knowledge areas distributed according to the contents of the slides.

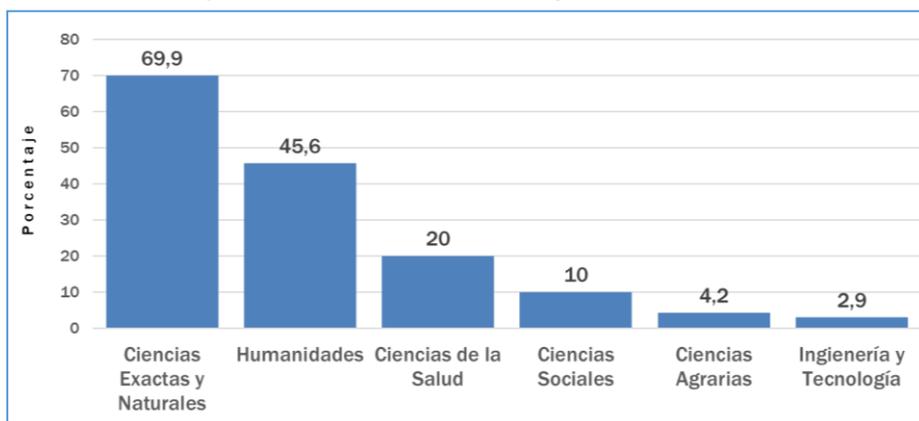
Figure 1. Distribution of the slides according to their scientific contents



Source: Compiled by author

The area of knowledge which was most commonly represented in the collections of the diascopic slides of our analysis was “Exact and Natural Sciences”. Figure 2 was created to show the results obtained, and it reveals a 69.9% for this sphere. This percentage shows that this type of slides is the one most commonly found in the collections of the secondary schools. At the other end of the spectrum we find the category “Engineering and Technology”, with 2.9%. The distribution of the different areas is shown in Figure 2.

Figure 2. Distribution of the slides according to their scientific contents (by area)



Source: Compiled by author

A good example of the type of collections in the category “Exact and Natural Sciences” can be seen in Image 2, created from a selection of zoology slides from the Instituto-Escuela which were used as a support for the identification of different species of animals and to prepare field trips. Within this group of slides we can find the image of two armadillos (*Tolypeutes*) —first image on the left—, that shows one animal in its normal state and another one showing the defensive strategy for this species, which rolls into a ball when in danger. In the specific case of armadillos, apart from the photographic slides, the students had a naturalized specimen of this animal in the laboratory.

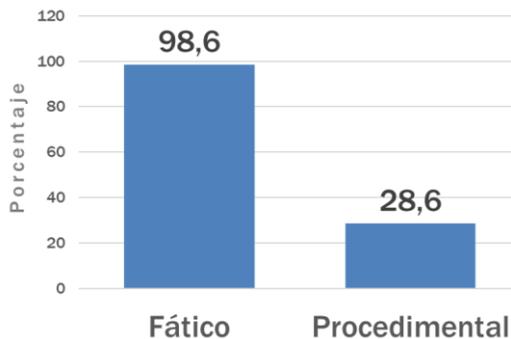
Image 2. Selection of 12 slides from the collection *Aufnahme nach Lebensbilder aus der Tierwelt Europas* (Benzinger)



Source: Compiled by author from the Collective Catalogue of Spain's Bibliographic Heritage

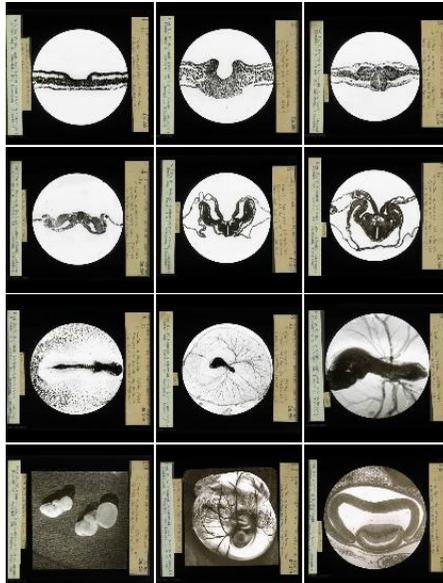
The second research question is related to the different educational approaches that represented academic contents in the collections of diascopic slides. Figure 3 shows the importance of the factual approach —followed at a distance by the procedural approach—, together with a complete lack of the other two approaches that had been considered: the dialectical and the speculative approaches. One example of a collection of diascopic slides that apply a factual framework can be seen in Image 3. It is a collection of slides on embryology —one of the disciplines of biology that enjoyed a boom in the first half of the 20th century— that emphasises the importance of faithfully representing the object of study through photographic or graphic images that showed a perspective without distortion, or in this case, that included a scale or an element that acted as a reference for the size of the object portrayed in the image.

Figure 3. Distribution of the most common educational approaches used in the slides



Source: Compiled by author

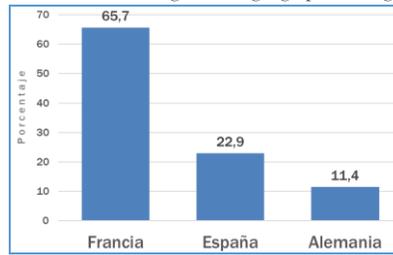
Image 3. The 12 slides from the collection *Lebensgeschichte eines Hühnchens im Ei* (Stempell) were used to illustrate embryology in the Instituto-Escuela



Source: Compiled by author from the Collective Catalogue of Spain's Bibliographic Heritage

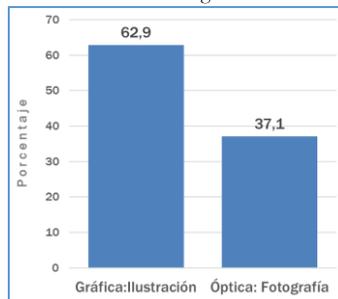
As we can see in Figure 4, France is the most common country of origin of the collections of slides in our study, followed by Spain and Germany. We must point out here the remarkable absence of collections from a country which was a great manufacturer of slides: the United Kingdom. The seventh and last question tried to determine the cultural traditions that were behind the academic contents in the collections of slides. Figure 5 shows the logical dominance of the visual tradition over the rest of cultural traditions —the literary and musical traditions are not even present here— associated to the cultural universe of audiovisual projections in the first third of the 20th century. If we analyse the results of this figure more closely, we can deduce that there is a predominance of the “graphic” visual tradition of “illustration” over the “optical” tradition of “photography”. In fact, diascopic slides often replaced and/or complemented illustrated sheets, drawings or maps that had been used for centuries in the classroom. Slides were often a replacement for large illustrations, because these were harder to transport and store due to their size. With the drawback of their fragility as the only exception, the transparencies had the advantage of being cheaper, maybe because some companies and collections included only the illustration so that the glass slide could be created in their final point of destination. We can see an example with the illustrations of Image 4, which shows 12 transparencies on the nervous system, the circulatory system or the respiratory system which must have been very useful as a support for the organ dissections that students carried out when they studied anatomy in the laboratories of the schools.

Figure 4. Distribution of the slides according to their geographical origin (country of production)



Source: Compiled by author

Figure 5. Distribution of the slides according to their cultural tradition of reference



Source: Compiled by author

Image 4. Gehirn und Nervensystem; Herz und Kreislauf (Liesegang, 8.5 x 10 cm)



Source: Compiled by author from the Collective Catalogue of Spain's Bibliographic Heritage

As a final reflection, it seems appropriate to confirm the significant role of diascopic slides in the secondary school classrooms of Spain during the first third of the 20th century. Their systematic use promoted the new educational models under “a new conception of the purpose of scientific education in secondary teaching: it had to be more formative and to prepare the students for their future learning in life” (Bernal, et al., 2007, p. 218). This propedeutic approach encompasses the set of concepts required to prepare the study of a topic, a science or a discipline. Students were required to attend laboratory practice regularly, and to visit museums or go to field trips, which were therefore part of

the teaching methods and their scientific training. In this context, and in an attempt to study scientific concepts in greater depth, glass slides on zoology, embryology, human anatomy, paleontology, geological formations or physical geography were often projected in the classroom. Apart from illustrating the discourse of the teacher, diascopic slides were tremendously useful in order to help students to observe nature —identifying specimens that were seen in field trips or interpreting the geological phenomena of geological excursions—, or to dissect the anatomy of all sort of specimens in the laboratory.

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